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THE JOURNAL OF RADIO RESEARCH & PROGRESS

MARCH 1952

VOL. XXIX No. 342 THREE SHILLINGS AND SIXPENCE

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			RATED	MAXIMUM				£ s. d.
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100-KM	2000 va.	115	15 a.	17.5 a.	0-115		20 watts	18 12 0
100-L	2000 va.	230/115	8 a.	9 a.	0-230		25 watts	17 17 0
100-LM	2000 va.	230/115	8 a.	9 a.	0-230		25 watts	18 12 0
100-Q	2000 va.	115	15 a.	17.5 a.	0-135		20 watts	18 9 0
100-QM	2000 va.	115	15 a.	17.5 a.	0-135		20 watts	19 4 0
100-R	2000 va.	230/115	8 a.	9 a.	0-270		30 watts	18 9 0
100-RM	2000 va.	230/115	8 a.	9 a.	0-270		30 watts	19 4 0
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500-L*	1450 va.	180	8 a.	9 a.	0-180		25 watts	17 17 0
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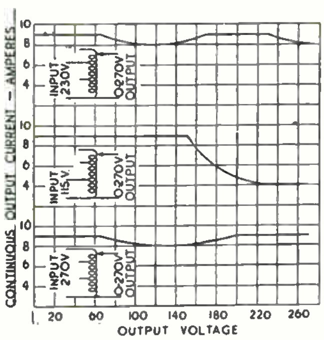

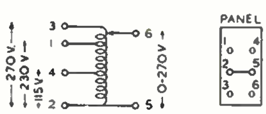

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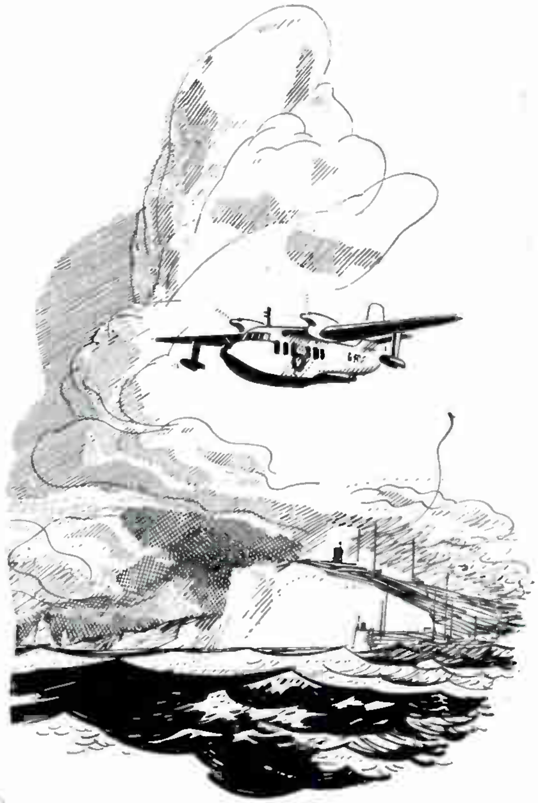


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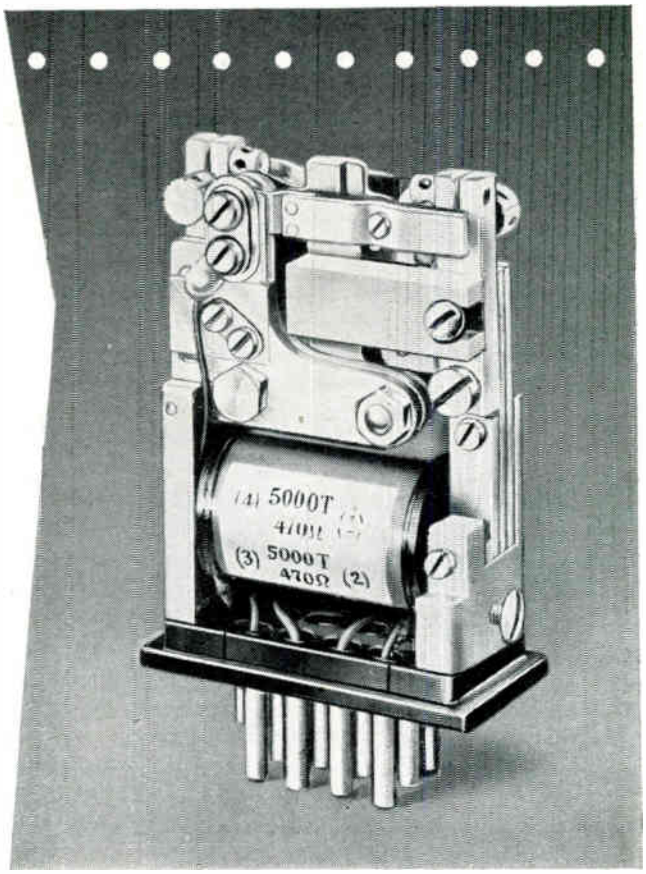

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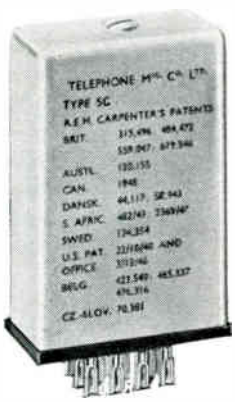

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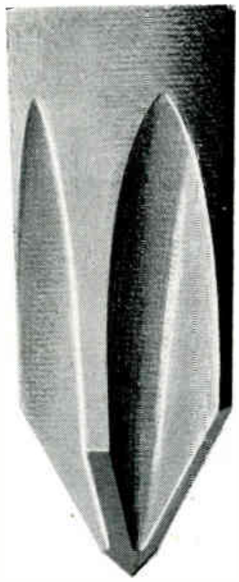

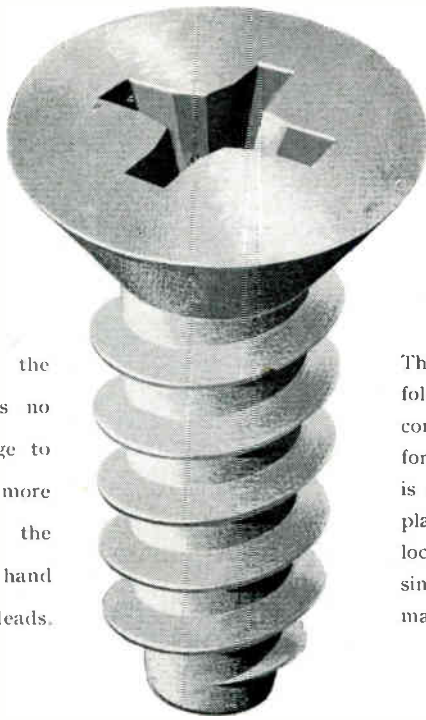

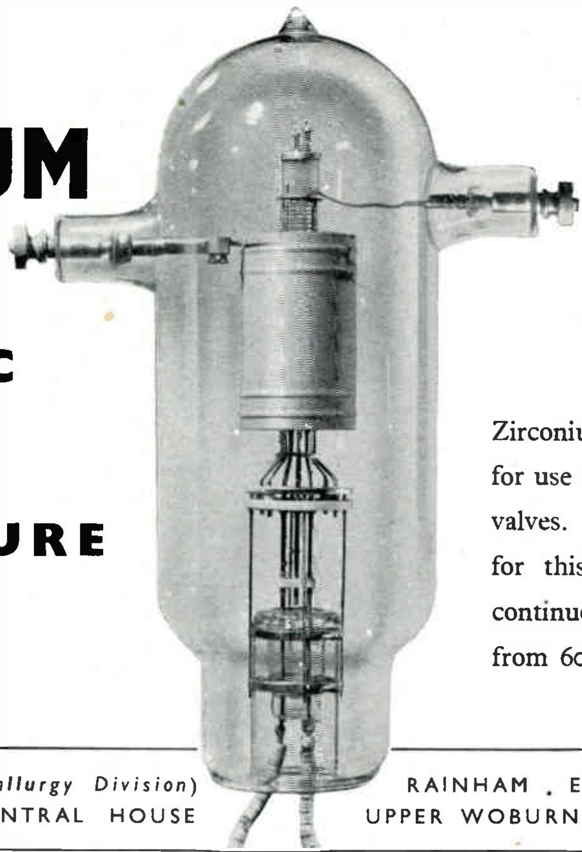

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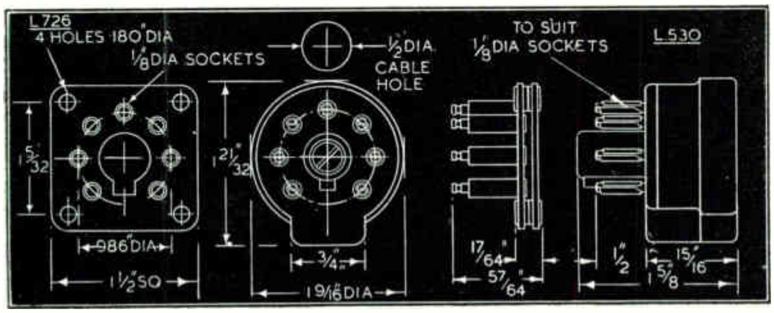

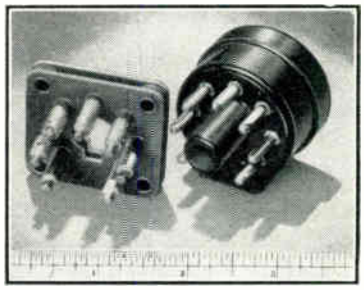

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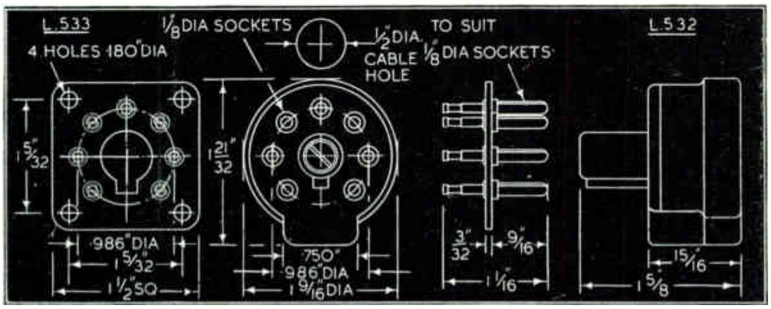
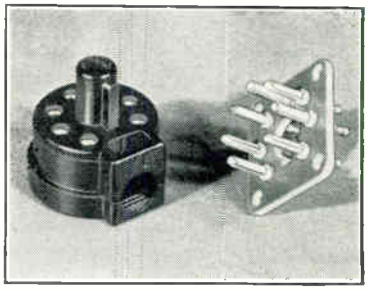
L. 331	**5-pole Chassis Socket**
L. 528	**5-pole Flex Plug**
L. 529	**5-pole Chassis Socket**
L. 550	**5-pole Flex Socket**
L. 551	**5-pole Chassis Plug**

These connectors are particularly suitable for rack-built equipment and connecting power pack to chassis, amplifier to receiver, etc.; their application to the electronic and electrical industry is very wide and they are well worth using, even with idle pins.

"O-Z" pins, semi-floating and silver-plated, giving low contact resistance, and facilitating soldering. A locating key is provided and no single pin can make contact until this is is in its correct position.





L. 530	**7-pole Flex Plug**
L. 726	**7-pole Chassis Socket**
L. 532	**7-pole Flex Socket**
L. 533	**7-pole Chassis Plug**
L.1244	**10-pole Flex Plug**
L. 332	**10-pole Chassis Socket**

The matching fit is exceptional, all pins making positive contact every time; can be coupled with eyes shut.

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MARCH 1952

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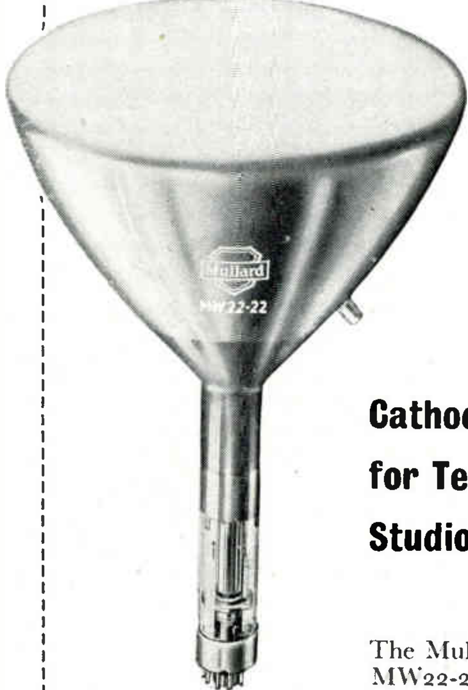

Cathode Ray Tubes for Television Studio Applications

DESCRIPTION	MW13-35	MW22-22
HEATER V_h I_h	6.3 V 0.3 A	6.3 V 0.3 A
LIMITING VALUES	absolute ratings	design centre ratings
V_{a2} max.	11 KV	11 KV
V_{a2} min.	5.5 KV	7 KV
V_{a1} max.	450 V	400 V
V_{a1} min.	200 V	200 V
$-V_g$ max.	200 V	150 V
DIMENSIONS		
Max. bulb diameter	127.5 mm	230 mm
Max. overall length	289 mm	377 mm
Useful screen diameter	108 mm	214 mm
BASE	Octal	B12A

The Mullard cathode ray tubes, MW22-22 and MW13-35, have been specially designed to give high-grade pictures under the brilliant lighting conditions encountered in television studio work. They are both characterised by their exceptionally high definition and high brilliance. Halation has been reduced to an absolute minimum.

The MW22-22, which is a metallized tube with a nine-inch, white screen, is now being used extensively in television studio monitoring.

The MW13-35, being a compact tube, is finding wide application in television-camera viewfinding equipments. This tube is also metallized and has a white, flat-faced screen, five inches in diameter.

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COMMUNICATIONS AND INDUSTRIAL VALVE DEPT.

MVT 112

WIRELESS ENGINEER

Vol. XXIX MARCH 1952 No. 342

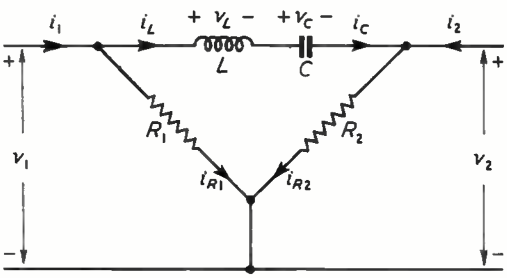
Duality between Triode and Transistor

It has long been known that one circuit or network can be replaced by another in which the roles of currents and voltages are interchanged. One network is then known as the dual, or perhaps more correctly, as the inverse of the other. Each element in the network is replaced by its dual, and the elements are then connected up in a dual manner, series connections being replaced by parallel connections and vice versa Although the roles of current and voltage are interchanged, their actual values and the ratio between them need not remain the same. To find the dual of an ordinary resistance R, the v in the equation $v = Ri$ is replaced by ri' and the i by v'/r, giving $i' = v'/(r^2/R)$. Hence the dual of R is a resistance r^2/R. The meaning of the constant r can be seen as follows:—if the current i' in the dual is 1 A, then $v' = r^2/R$, but $v' = ir$, hence $r = Ri = v$; that is, r is equal to the voltage across R corresponding to unit current through the dual. The same applies to a capacitor where, in the equation, $v = \frac{1}{j\omega C} i$ v and i are replaced by $i'r$ and v'/r, giving

$$i' = \frac{1}{jr^2 C\omega} v'$$

which is the equation for an inductance of $L' = r^2C$, which is therefore the dual of the capacitor.

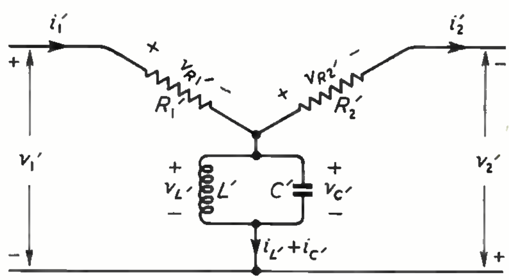
As an example of network duality we shall consider the networks shown in Fig. 1.* The nodes of one, to which Kirchhoff's first law applies, have as their duals the meshes of the other to which Kirchhoff's second law applies. A constant-voltage supply V becomes a constant-current supply $I' = V/r$ and vice versa. In Fig. 1(a) we have a mesh, one side of which consists of an inductance L and a capacitance C in series, while the other two sides are simple resistances R_1 and R_2. The voltages across R_1 and R_2 are v_1 and v_2 as shown. The dual network is given in Fig. 1(b). To see that this is so it is only necessary to write down the Kirchhoff equations for Fig. 1(a) and then transform all the currents into the dual voltages and vice versa, thus:—



(a)

Fig. 1(a)

$$i_1 - i_L - i_{R1} = 0;\ v_1 = v_{R1}$$
$$i_2 + i_C - i_{R2} = 0;\ v_2 = v_{R2}$$
$$v_1 - v_L - v_C - v_2 = 0;\ i_L = i_C$$



(b)

Fig. 1(b)

$$v'_1 - v_{L'} - v_{R1'} = 0;\ i'_1 = i_{R1'}$$
$$v'_2 + v_{C'} - v_{R2}' = 0;\ i'_2 = i_{R2'}$$
$$i'_1 - i_{L'} - i_{C'} - i'_2 = 0;\ v_{L'} = v_{C'}$$

* This is taken from an article by Wallace and Raisbeck in the *Bell System Technical Journal*, Sept. 1951, p. 390.

The actual values will depend on the values of the transforming resistance r which must be chosen to suit the terminal conditions.

A somewhat similar relationship exists between an ordinary triode valve and a transistor. In one form of the latter two 'cat's whiskers' make contact with the upper face of a small plate of germanium which has a metal base; the two upper contacts may consist of phosphor-bronze wires about 0·002 in. diameter, the contact points being a few thousandths of an inch apart. The germanium may be in either of two states; in n-Ge the current is due to the movement of negative electrons as in an ordinary conductor, but in p-Ge it is due to the movement of 'holes' which is equivalent to the movement of positive charges. We shall assume that we are dealing with the

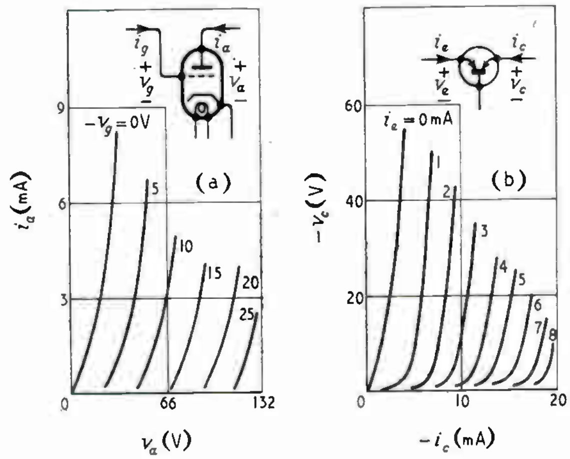


Fig. 2.

former. The input electrode—the equivalent to the grid—is called the emitter, and the output electrode—the equivalent to the anode—is called the collector.

On comparing the properties of the triode and transistor nearly everything seems reversed. Whereas the triode has a high input impedance and a relatively low output impedance, in the transistor these are reversed. To obtain maximum amplification the triode grid is biased by a voltage in the reverse direction, whereas the transistor emitter is biased by passing a current in the forward direction; similarly the battery in the output circuit is reversed. As a rough approximation one can say that the relations between currents and voltages in the triode can be applied when reversed to the transistor. By carefully choosing the triode a close approximation to duality can be obtained. This is shown by Fig. 2 which gives the results obtained by Wallace and Raisbeck for (a) a triode and (b) a transistor. In the latter the emitter bias is given in positive milliamperes instead of negative volts and $-v_c$ is plotted against $-i_c$ instead of i_a against v_a. By making these changes, one obtains a very similar set of characteristic curves. It is seen that 66 V on the (a) base corresponds approximately to 10 mA on the (b) base, giving a transformation resistance of 6600 ohms. The same result is obtained from the ordinates of 3 mA and 20 V, but if the values of v_g on the (a) curves are compared with the values of i_e on the corresponding (b) curves, it is seen that they agree with a transformation resistance of only about 3300 ohms. This indicates a weak spot in the duality of the two devices.

Since on replacing a triode by a transistor the relations between currents and voltages are approximately interchanged, the network or circuit attached to the triode must be replaced by its dual. There is one point, however, at which the duality of the triode and transistor breaks down. The signs of the output current and voltage are opposite to what they would be in a perfect dual, but this can be completely corrected by inserting a transformer at the output terminals. A large number of suitable circuits are considered in an appendix to the paper by Wallace and Raisbeck to which we have referred.

G. W. O. H.

SLIDEBACK AND INFINITE-IMPEDANCE VOLTMETERS

Response to Signal and Noise

By R. E. Burgess, B.Sc.

(Communication from the National Physical Laboratory)

SUMMARY.—The present paper extends the analysis in an earlier paper to two types of voltmeter which have been used for the measurement of signal and noise. In the slideback voltmeter the increase of mean current through a diode or a triode upon the application of signal or noise is offset by additional negative bias, the increase of bias providing the measure of the input voltage. Contrary to common belief, this type of voltmeter gives indications of less than the true peak voltage of a c.w. signal, and furthermore, for noise, the slideback voltmeter behaves as a square-law instrument.

The infinite-impedance voltmeter is shown to have the same rectification characteristics as a simple diode voltmeter without the disadvantage of consuming power from the source.

Curves are given for the rectification characteristics of the three types of voltmeter (simple diode, slideback and infinite-impedance) for c.w. signals and for fluctuation noise applied separately: formulae give the response to any arbitrary mixture of signal and noise. It is assumed throughout that the current vs. voltage characteristic of the valve is exponential over the range of applied voltage, and the analysis should therefore be valid for input voltages up to about 1 volt r.m.s.

1. Introduction

THE performance of the diode and the anode-bend voltmeters for c.w. and for fluctuation noise was discussed in an earlier paper.[1] In the present paper two types of valve voltmeter are considered which have been used for noise measurement and which have certain interesting features.

The slideback voltmeter is so called because, after applying the signal to the rectifying valve (diode in Fig. 1 or triode in Fig. 2), it is biased back by manual adjustment until the current through the valve is the same as it was before the application of the signal. The bias voltage then provides a measure of the applied signal. The claim that this type of instrument indicates the true peak value of a signal or noise wave more accurately than the normal diode voltmeter, which is sometimes termed a 'quasi-peak' instrument, is discussed.

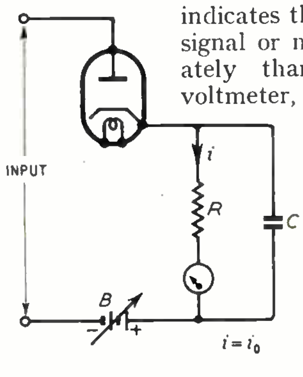


Fig. 1. *Diode slideback voltmeter. The mean rectified current i in the presence of a signal is made equal to the initial current i_0 in the absence of a signal by adjustment of the bias voltage B.*

In the analysis presented here the following assumptions are made:

(i) the current through the valve is always sufficiently small for the current vs. voltage characteristic to be exponential; i.e., of the form

$$i = J \exp (Kv) \quad \ldots \quad (1.1)$$

where J and K are constants for the particular valve used. In an indirectly-heated diode K is usually about 10 V^{-1}, but will be considerably smaller in a triode;

(ii) the time constant of the load circuit in the case of the diode voltmeter is long compared with the reciprocal of the bandwidth of any noise applied to it so that the voltage appearing across the load remains substantially constant during the application of a noise-voltage input.

For generality, the input voltage is taken as a mixture of a c.w. signal of amplitude S and of fluctuation noise having a normal probability distribution and an r.m.s. value E. By putting either E or S equal to zero the rectification properties of the voltmeter for signal alone or for noise alone are then derived as special cases.

In the infinite-impedance voltmeter (Fig. 3) there is a large cathode-load resistance (shunted by a capacitor C) and the bias it provides (possibly supplemented by additional fixed bias) is arranged to bring the operating point to cut-off. On applying a signal to the valve grid the anode rectification causes the mean current to increase, so augmenting the self-bias voltage developed in R until equilibrium is established. The increase in direct voltage across R then provides a measure of the applied signal. This voltmeter has the feature of functioning in the same manner as the simple diode voltmeter (Fig. 4), but with freedom from the damping of the latter since no current is drawn by the grid.

MS accepted by the Editor, March 1951

2. Slideback Diode Voltmeter

Let the input voltage to the diode voltmeter (Fig. 1) consist of a mixture of a c.w. signal of amplitude S and fluctuation noise of r.m.s. voltage E. The average diode current $\bar{i}$ is found by averaging over all phases ϕ of the sine-wave signal and over the normal distribution of the instantaneous noise voltage v. Thus

$$\bar{i} = J \exp(-KV - KB)\,\overline{\exp[K(S\cos\phi + v)]}$$

$$= J \exp(-KV - KB)\int_{-\infty}^{+\infty}\frac{dv}{\sqrt{2\pi}E}\cdot\exp\left(-\frac{v^2}{2E^2}\right)\int_0^{\pi}\frac{d\phi}{\pi}\exp K(S\cos\phi - v)$$

$$= J\,I_0(KS)\exp(\tfrac{1}{2}K^2E^2 - KV - KB) \quad .. \quad .. \quad .. \quad (2.1)$$

where B is the bias voltage applied to the diode and V is the rectified voltage $\bar{i}R$ built up across the load resistor. I_0 is the modified Bessel function of the first kind and zero order.

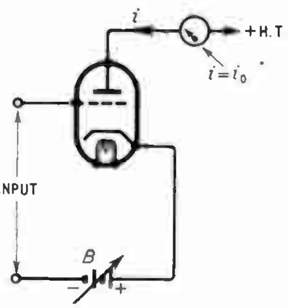


Fig. 2. *Triode slideback voltmeter. The mean anode current i in the presence of an input signal is made equal to the initial anode current i_0 in the absence of a signal by adjustment of the bias voltage B.*

Now the operation of the slideback voltmeter consists in adjusting the bias B until the mean current is brought to the value i_0 which exists when there is no input voltage and no bias. Then

$$i_0 = J\exp(-KV_0) \text{ where } V_0 = i_0R \quad .. \quad (2.2)$$

Hence when $\bar{i} = i_0$ and thus $V = V_0$ we have

$$B = \tfrac{1}{2}KE^2 + \frac{1}{K}\log I_0(KS) \quad .. \quad .. \quad (2.3)$$

This relates the slideback bias to the noise and signal in a simple form in which their respective contributions are seen to be directly additive. It is noted that neither the parameter J of the diode nor the load resistance R enter into this equation. Some special cases are worth considering:

(i) *No noise, signal alone*

$$B = \frac{1}{K}\log I_0(KS) \quad .. \quad .. \quad .. \quad (2.4)$$

The rectification efficiency is thus:

$$\gamma = \frac{B}{S} = \frac{\log I_0(KS)}{KS} \quad .. \quad .. \quad (2.5)$$

and this is shown in the upper curve of Fig. 5 as a function of KS (marked $b = \infty$). This relation was first derived by Aiken and Birdsall[2] in 1938. When the signal is small ($KS < 1$) the efficiency is proportional to the signal and thus the voltmeter behaves as a square-law indicator. Equation (2.4) gives

$$B \approx \frac{1}{4}KS^2 \quad .. \quad .. \quad .. \quad .. \quad (2.6)$$

For large signals ($KS > 10$) the efficiency is greater than 0·8 and the voltmeter approaches a peak indicator. Then from equation (2.4)

$$\gamma \approx 1 - \frac{\log 2\pi KS}{2KS} \quad .. \quad .. \quad .. \quad (2.7)$$

by virtue of the asymptotic form of I_0.

(ii) *No signal, noise alone*

$$B = \tfrac{1}{2}KE^2 \quad .. \quad .. \quad .. \quad .. \quad (2.8)$$

This relation is shown in the upper curve of Fig. 6.

The voltmeter is seen to be a square-law device and has the same factor of proportionality ($\frac{1}{2}K$) between the bias and the mean-square voltage as for a small c.w. signal [equation (2.6)].

(iii) *Small signal and noise*

If $KS < 1$ and noise (of any level) is present

$$B = \tfrac{1}{2}K(E^2 + \tfrac{1}{2}S^2) \quad .. \quad .. \quad .. \quad (2.9)$$

showing that the voltmeter indicates the mean-square voltage of the mixture.

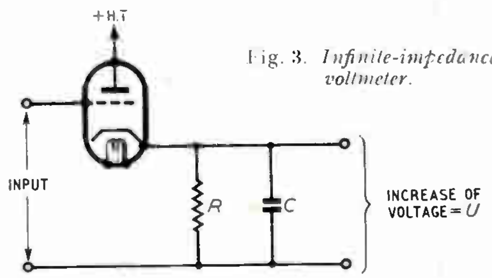


Fig. 3. *Infinite-impedance voltmeter.*

A restriction on the validity of this analysis should be pointed out here. It is assumed that the diode has an exponential characteristic, and in practice this implies that the anode is never more than a fraction of a volt positive with respect to the cathode. This condition is certainly realized on steady signals, but in the case of noise the peaks of large amplitude will tend to carry the anode more positively than the cathode, whose potential is held substantially steady by the load capacitor C providing the large time constant. Thus the upper limit of noise voltage for which the purely square-law behaviour on noise is obeyed should be determined experimentally for any particular circuit used for noise measurements.

Despite these limitations of the postulated exponential characteristic, which must in any event be valid for small input voltages, it is seen that the slideback voltmeter behaves more like a true peak voltmeter than the usual type of diode voltmeter for a c.w. signal but, as Fig. 5 shows, the difference may be small. On noise the slideback voltmeter behaves as a square-law instrument.

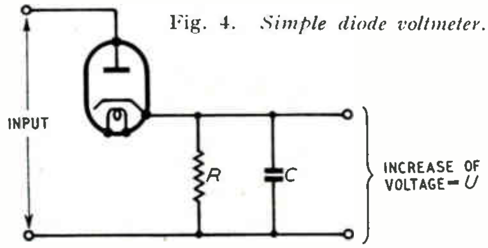


Fig. 4. *Simple diode voltmeter.*

3. Slideback Triode Voltmeter

The triode slideback circuit (Fig. 2) differs from the diode voltmeter in that there is no build-up of rectified voltage to produce self-bias (this actually occurs in the infinite-impedance detector considered in the next section). If B_o is the initial bias with no applied signal the anode current of the valve which is near the cut-off condition will be

$$i_o = J \exp(-KB_o) \quad \ldots \quad (3.1)$$

Now when a mixture of signal S and noise E is applied let the bias be increased by B to $B + B_o$ so that the mean anode current $\bar{i}$ is equal to i_o. Then

$$\begin{aligned} i_o &= \bar{i} \\ &= J \exp(-KB_o - KB)\, \overline{\exp K(S\cos\phi + v)} \\ &= J\, I_0(KS) \exp(-KB_o - KB + \tfrac{1}{2}K^2E^2) \end{aligned} \quad \ldots \quad (3.2)$$

where the double integral is as in equation (2.1) and is denoted here by an average.

$$\text{Thus } B = \tfrac{1}{2}KE^2 + \frac{1}{K}\log I_0(KS) \quad \ldots \quad (3.3)$$

which is *exactly* the same as equation (2.3) for the diode voltmeter. The reason that the self-biasing action in the diode voltmeter does not affect the result is that since $\bar{i} = i_o$ in the measuring condition, also $V = V_o$ and the voltage across the diode load does not therefore enter into the final relation.

Hence the discussion of equation (2.3) in the previous section and the upper curves of Figs. 5 and 6 apply equally to the triode voltmeter.

However, it must be remembered[3] that although the parameter K will be about 10 V^{-1} for an indirectly-heated diode, it will be less in a triode (e.g., between 0·5 and 5 V^{-1}) and therefore the voltmeter will be less efficient and less linear with a triode than with a diode.

4. Infinite-Impedance Voltmeter (Fig. 3)

In the infinite-impedance voltmeter of Fig. 3 the cathode resistor R of the triode is relatively large (10^4 ohms or greater usually) in order to provide sufficient self-bias to bring the grid potential near to cut-off and to ensure essentially peak rectification. In practice it may be necessary to introduce an additional fixed negative bias to achieve cut-off without using a prohibitively large cathode resistor. The resistor is shunted by a capacitor C in order to give a suitably large time constant.

Again it is assumed that the anode current is exponentially related to the grid voltage:

$$i = J \exp(-Kv_g) \quad \ldots \quad (4.1)$$

whence the anode current i_o in the absence of an applied signal is given by

$$i_o = J \exp(-KRi_o) \quad \ldots \quad (4.2)$$

When a c.w. signal of amplitude S and noise of r.m.s. voltage E are together applied to the input the mean anode current is given by

$$\begin{aligned} \bar{i} &= J \exp(-KR\bar{i})\, \overline{\exp K(S\cos\phi + v)} \\ &= J \exp(-KR\bar{i})\, I_0(KS) \exp(\tfrac{1}{2}K^2E^2) \end{aligned} \quad \ldots \quad (4.3)$$

In this voltmeter $\bar{i}$ is not made equal to i_o as in the slideback type, but its excess over i_o is used as a measure of the applied voltage. Thus if the increase U of cathode voltage is used as the indication

$$\begin{aligned} U &= R(\bar{i} - i_o) \\ &= Ri_o\left[\exp(-KU + \tfrac{1}{2}K^2E^2)\, I_0(KS) - 1\right] \end{aligned} \quad \ldots \quad (4.4)$$

Putting $b = KRi_o$ and rearranging gives

$$\left(1 + \frac{KU}{b}\right) e^{KU} = \exp(\tfrac{1}{2}K^2E^2)\, I_0(KS) \quad (4.5)$$

Now this relation is identical with that for a simple diode voltmeter (Fig. 4) having the same parameters K and b, as given in the earlier paper.[1] The advantage of the infinite-impedance voltmeter over the diode voltmeter is that it draws no power from the source of input voltage.

Three special cases of equation (4.5) will be considered briefly:

(i) For small input signal and noise (KE and $KS \ll 1$)

$$U \approx \frac{\tfrac{1}{2}K^2Ri_o}{1 + KRi_o}(E^2 + \tfrac{1}{2}S^2) \quad \ldots \quad (4.6)$$

which shows that the instrument behaves as a square-law voltmeter.

(ii) For signal alone applied to the input ($E = 0$) we have the result

$$e^{KU}\left(1 + \frac{KU}{b}\right) = I_0\,(KS) \qquad .. \quad (4.7)$$

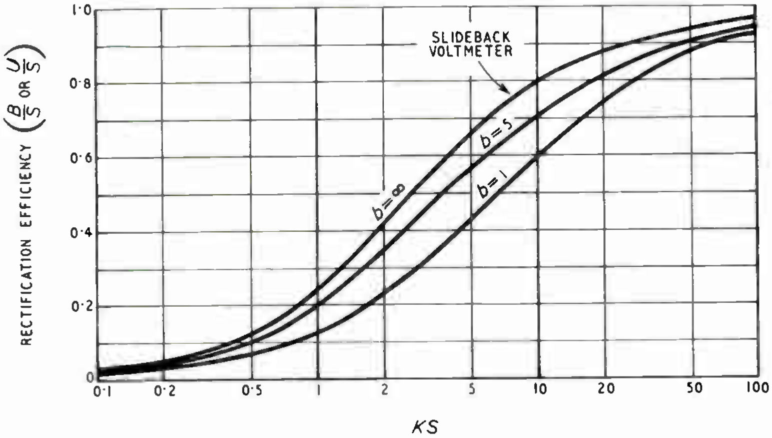


Fig. 5. *Rectification efficiency of various voltmeters for c.w. signals. $b = K \times$ load resistance $R \times$ initial current i_0; B = increase of bias in slideback voltmeter; U = increase of rectified voltage in diode and infinite-impedance voltmeters; S = signal amplitude; K = parameter of valve characteristic.*

This relation is shown graphically in Fig. 5 for $b = 1$, 5 and ∞. If b is large compared with unity, the rectification voltage is closely given by

$$U = \frac{1}{K}\log I_0\,(KS) \qquad .. \quad .. \quad .. \quad (4.8)$$

exactly as for the slideback diode or triode voltmeters. In fact as b tends to infinity by making R very large, the infinite-impedance voltmeter can be regarded as a device in which the slideback action is achieved automatically by the self-biasing effect of R.

(iii) For noise alone applied to the input ($S = 0$) equation (4.5) becomes

$$\left(1 + \frac{KU}{b}\right) e^{KU} = \exp\,(\tfrac{1}{2}K^2E^2) \qquad .. \quad (4.9)$$

Thus the voltmeter will tend to indicate the mean-square voltage rather than the r.m.s. voltage at all levels of input noise voltage. The curves in Fig. 6 show KU as a function of K^2E^2 for $b = 1$, 5 and ∞, these values embracing most cases of practical interest. When b is large the straight line for $b = \infty$ is very nearly valid and the voltmeter behaves as a true square-law instrument. When b is small the indications are reduced but the instrument is still essentially a square-law device, as may be seen from the sensibly linear relation between KU and K^2E^2.

Remembering that the infinite-impedance voltmeter has the same behaviour as a simple diode voltmeter, it is seen that so long as the postulated exponential current vs. voltage characteristic is valid both instruments indicate as square-law devices on noise over a much larger range of r.m.s. input voltage than on c.w.

Acknowledgments

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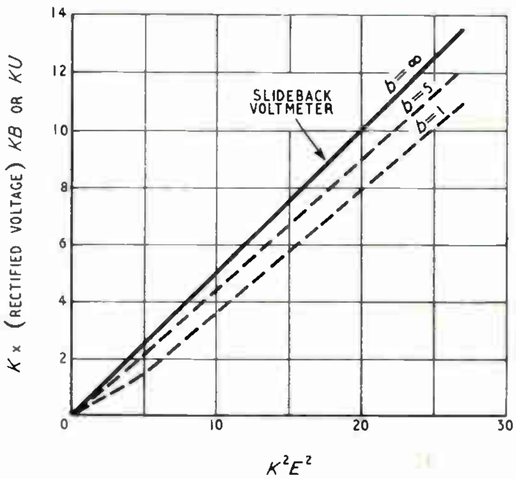

Fig. 6. *Response of various voltmeters to fluctuation noise. (All curves are applicable to the simple diode voltmeter and the infinite-impedance voltmeter. The upper curve is applicable to the slideback type of voltmeter.) K = parameter of valve characteristic; $b = K \times$ load resistance $R \times$ initial current i_0; E = r.m.s. input noise voltage; B = increase of bias in slideback voltmeter; U = increase of rectified voltage in diode and infinite-impedance voltmeters*

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CATHODE-COUPLED AMPLIFIER

Analysis and Design

By J. A. Lyddiard, B.Sc., A.M.I.E.E.

SUMMARY.—The usual equivalent network representing the cathode-coupled amplifier stage leads directly, using Kirchhoff's Laws, to a cumbersome formula which does not give a clear picture of the performance or assist in simple and rapid design procedure. The analysis presented in this paper treats this amplifier stage as a cathode-follower driving an earthed-grid voltage amplifier, which results in a very simple analysis and clearly indicates a sound procedure for design work.

Introduction

THE cathode-coupled amplifier to be considered in this paper is shown in Fig. 1, an equivalent network of which is given in Fig. 2. Application of Kirchhoff's Laws to this network and the solution of the resulting simultaneous equations result in a formula for the gain:

$$A = \frac{\mu_1(\mu_2 + 1)R_L R_k}{r_{a1}r_{a2} + r_{a2}R_L + r_a R_{1k}(\mu_2 + 1) + R_k\,(\mu_1 + 1)(r_{a2} + R_L)} \quad \ldots \quad (1)$$

It is, perhaps, superfluous to stress that although the two valves may be identical, they may be operated at considerably different magnitudes of anode current, which necessitates distinct symbols for the parameters of both valves in the formula. As pointed out by Ross,[1] it is tedious but not difficult to obtain the magnitude of all these parameters by means of graphical analysis. The method does not take into account non-linear distortion, nor does it readily lend itself to the development of such calculations.

Theory

In theoretical work of this nature, it is well-established practice to ignore distortion for the first analysis and to make modifications to account for non-linearity, etc., at a later stage. Accordingly, we shall assume linear operation of the valves and neglect stray reactances. The circuit of Fig. 1 is redrawn in Fig. 3, so as to stress that the stage may be regarded as two stages; a cathode-follower driving an earthed-grid amplifier. Thévenin's theorem may be applied at points AB (see Figs. 2 and 3) if care is taken to consider the subsidiary effects of removing that branch of the network in which flows the current (I_o) to be calculated. This is the branch to the right of AB in the diagrams. When this is removed the first valve becomes a single cathode-follower with a load resistance R_k (Fig. 4). The

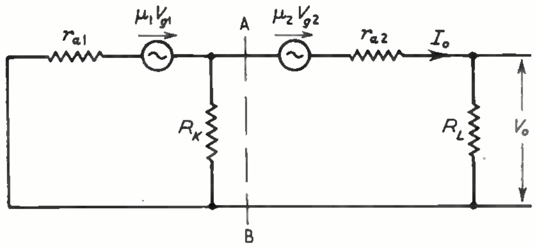


Fig. 2. *Equivalent circuit of Fig. 1.*

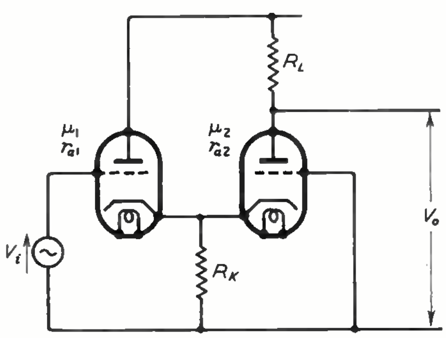


Fig. 1. *Circuit of cathode-coupled amplifier.*

MS accepted by the Editor, December 1950

voltage developed across R_k, in this condition, and the output impedance of the equivalent generator may then be calculated.

The magnitude of the grid-cathode voltage of the first valve then becomes (Fig. 4):

$$V_{g1} = V_i - IR_k \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

This fails to take into account the effect upon the magnitude of V_{g1} of the current flowing in R_k due to the second valve. This is accounted for below.

Completing the analysis for determining the voltage V_2 across R_k with the 'load' branch removed, we have:

from Fig. 4. $I = \dfrac{\mu_1(V_i - IR_k)}{r_{a1} + R_k}$

giving
$$V_2 = \frac{\left(\dfrac{\mu_1}{\mu_1 + 1}\right)R_k V_i}{\dfrac{r_{a1}}{\mu_1 + 1} + R_k} \quad \ldots \quad (3)$$

The effective output impedance of the valve is, therefore, $\dfrac{r_{a1}}{\mu_1 + 1}$, and of the valve plus cathode load (R_k):

$$r = \frac{\left(\dfrac{r_{a1}}{\mu_1 + 1}\right) R_k}{\dfrac{r_{a1}}{\mu_1 + 1} + R_k}$$

$$\therefore r = \frac{R_k}{1 + g_{m1} R_k \left(\dfrac{\mu_1 + 1}{\mu_1}\right)} \quad \ldots \quad \ldots \quad (4)$$

where g_{m1} is the mutual conductance of the first valve. The voltage across R_k when the circuit is opened at AB is, therefore:

$$V_2 = \frac{\left(\dfrac{\mu_1}{\mu_1 + 1}\right) R_k V_i}{\left(\dfrac{r_{a1}}{\mu_1 + 1}\right) + R_k}$$

$$= g_{m1} r V_i \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

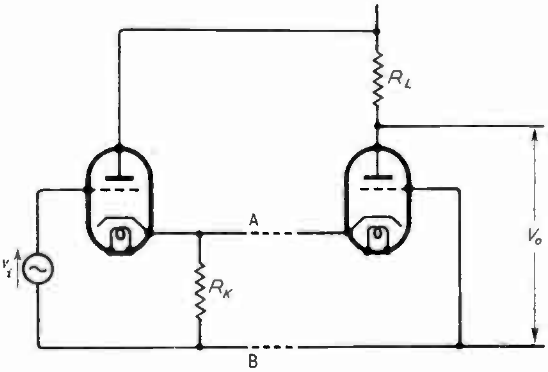


Fig. 3. *Here Fig. 1 is re-drawn to show its equivalence to a cathode follower plus an earthed-grid stage.*

This represents the well-known equivalent generator for the cathode-follower, in which the load resistance is not assumed large compared with $1/g_{m1}$, and on completing the application of Thévenin's theorem, results in an equivalent network for the complete amplifier as shown in Fig. 5, from which Fig. 6 follows directly. From Fig. 6(b) we see that:

$$I_o = \frac{\mu_2 V_{g2} + g_{m1} r V_i}{r_{a2} + r + R_L} \quad \ldots \quad \ldots \quad (6)$$

But $V_{g2} = g_{m1} + rV_i - I_o r$

which, upon substitution in (6) gives:

$$I_o = \frac{g_{m1} r V_i + \mu_2 (g_{m1} r V_i - I_o r)}{r_{a2} + r + R_L}$$

$$\therefore I_o = \frac{g_{m1} r (\mu_2 + 1) V_i}{r_{a2} + r(\mu_2 + 1) + R_L} \quad \ldots \quad \ldots \quad (7)$$

The effect of I_o flowing in R_k is accounted for here, since the input impedance of the second valve $\left(\dfrac{r_{a2} + R_L}{\mu_2 + 1}\right)$ has been connected to the output terminals of the first valve, for which the output impedance is correctly represented by r.

Hence we have the stage gain:

$$A = \frac{g_{m1} r R_L (\mu_2 + 1)}{r_{a2} + r(\mu_2 + 1) + R_L} \quad \ldots \quad \ldots \quad (8)$$

and the output impedance

$$R_{out} = \frac{R_L[r_{a2} + r(\mu_2 + 1)]}{r_{a2} + r(\mu_2 + 1) + R_L} \quad \ldots \quad \ldots \quad (9)$$

Feedback Voltages

The analysis takes into account the feedback voltages in the amplifier in the following manner:

The 100% feedback associated with the cathode follower stage is unaffected by the magnitude of its load impedance. Consequently there is no error from this source, and the effect upon the cathode load of connecting the second valve has been accounted for in the equation for I_o [equation (7)]. Thus the feedback due to the anode current of the second valve flowing in the cathode load of the first has been accounted for. If it is necessary to compute harmonic distortion in the first valve (which is very unlikely) the true a.c. loading on this stage must be calculated and graphical analysis carried out in the usual way.

The feedback in the second stage due to the resistance r (Fig. 5) is also accounted for in equation (7). It may be necessary to know this separately for harmonic distortion computation, and its magnitude is given by:

$$\beta_2 = \frac{r}{R_L} \quad \ldots \quad \ldots \quad (10)$$

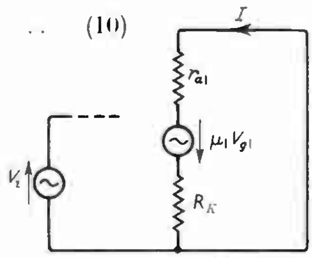


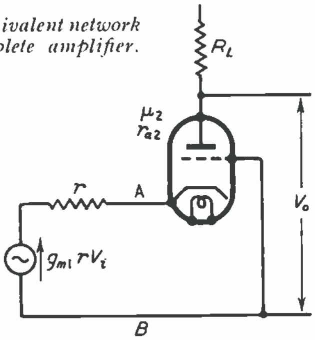
Fig. 4. *Equivalent circuit of the cathode follower part of the amplifier.*

Harmonic Distortion

The harmonic distortion introduced by the cathode-follower will depend upon the magnitude of the driving voltage and upon the a.c. loading of the stage. It may be computed by graphical means by drawing the load line represented by the resistance R_k shunted by the driving-point impedance of the earthed-grid stage. In the present application this is unnecessary since the driving voltage will always be well below that which would cause appreciable harmonic distortion in the cathode-follower.

The current feedback due to β_2 in the earthed-grid stage will produce a reduction of harmonic distortion which can be readily calculated.

Fig. 5. *Equivalent network of the complete amplifier.*



Generalization

Although the argument, as presented here, is much more lengthy than the simple solution of the equations for the network of Fig. 2, the actual performance of the analysis is not difficult and the results are obtained in a much more convenient form for design purposes. The method may equally well be applied to other types of cathode-coupled amplifier such as the 'phase inverter.' From the instructional point of view the analysis shows off the properties of this type of connection much more clearly. The earthed-grid amplifier may be treated separately and its freedom from Miller effect, its low input impedance and its reduced load-shunting capacitance demonstrated. The cathode-follower is also seen quite separately; and the connection of the two stages may be easily shown to give a coupling which has all the advantages of direct coupling, without causing heavy loss of gain due directly and indirectly to the necessity for backing off the positive bias on the second grid, which arises in the normal earthed-cathode connection.

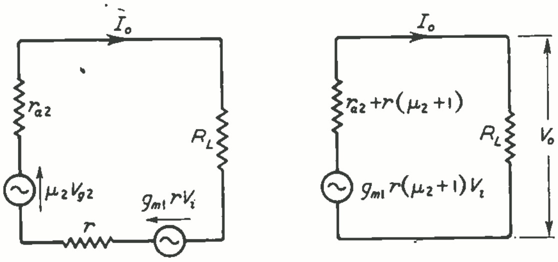
Design

The design procedure depends, as is usual in voltage amplifiers, upon the required output voltage level and upon the required bandwidth.

If the output voltage is to be small the design may be based entirely upon the formulae developed above and the normal published characteristics of the valves. A wide bandwidth merely imposes a limitation upon the magnitude of the output impedance of the stage and thus also upon R_L.

Large output requirements will impose a limit upon the usefulness of the formulae if the distortion produced is appreciable. The gain can then be found by the usual graphical analysis, but the formula should be sufficiently accurate for the output impedance, since its limitation is based upon a rough estimate of shunt capacitance. It will rarely occur, however, that the non-linearity which can be tolerated is so large that the gain may not be found from the formula. The ease with which the design may be carried out will be demonstrated using the published curves of the 6SN7 double-triode (Brimar), which it is not considered necessary to reproduce here. Low-level operation will be assumed, first of all, and no bandwidth restriction will be considered.

Since the feedback in the earthed-grid stage is not large, and since the curve of gain versus R_L is very blunt, it is permissible to treat this stage isolated from the cathode-follower for a rough assessment of the optimum load resistance. Table 1 may be drawn up showing the variation of gain of such a stage with load resistance. For simplicity it will be assumed that the grid bias is to be the same for both valves. This would be the case if it were not desired to tap the cathode-coupling resistor in order to adjust the grid bias, which would involve the use of an RC decoupling network to avoid additional feedback. An anode supply of 250 V will be used throughout the examples which follow.



(a) (b)

Fig. 6. *Further equivalent circuits as reductions of Fig. 5.*

Inspection of a set of characteristic curves for the 6SN7 (Brimar) will show that the grid bias should not be less than 7·5 V, otherwise the maximum anode dissipation will be exceeded in the cathode-follower stage.

Table 1 shows the variation of gain with load resistance for the earthed-grid stage under these conditions.

TABLE 1

R_L (kΩ)	I_{a2} (mA)	μ_2	r_{a2} (kΩ)	Gain
25	2·8	18·8	14·0	12·0
50	1·7	17·9	18·6	13·0
100	0·9	17·0	26	13·5
200	0·5	16·6	36	14·5

Now, the anode current of the cathode-follower will be constant at 10 mA for all values of R_k as long as the grid bias is held at $-7 \cdot 5$ V. Hence the smaller the anode current in the second valve, the larger will be the common cathode resistance required to give the desired bias. It will be observed, as the design proceeds, that the values obtained for R_k tend to be small enough to cause appreciable loss in the cathode-follower stage. Consequently it is likely to give an improvement in overall gain if the anode load resistance is made somewhat large, since this will allow a larger value of R_k to be used.

Let $R_L = 200$ kΩ
Then $I_{a1} = 10$ mA,
$I_{a2} = 0 \cdot 5$ mA,
$V_g = -7 \cdot 5$ V.

Since we have a rough idea of the gain of the earthed-grid stage, it remains to see if there is appreciable loss in the cathode-follower stage before being more exact.

R_k may be calculated from the published curves for the 6SN7, as follows:

$$R_k = \frac{V_g}{I_{a1} + I_{a2}}$$

$$= \frac{7 \cdot 5}{10 \cdot 5} \text{ k}\Omega = 715\ \Omega$$

The response of the first stage may now be checked:—

From the published curves we find:

$$g_{m1} = 3 \cdot 0 \text{ mA/V}$$

$$\therefore \frac{1}{g_{m1}} = 333\ \Omega$$

Hence the output/input voltage ratio for this stage alone will be:

$$A_1 = \frac{715}{715 + 333} = 0 \cdot 7$$

This is 3 db below the possible response and can be improved by increasing R_k. This, of course, involves an increase in grid bias.

A new value of grid bias may now be tried and, if R_k is suitably increased, the work may be concluded without again checking A_1.

Thus for $V_b = 250$ V, $V_g = -8 \cdot 5$ V
the optimum load is $R_L = 150$ kΩ
and $I_{a1} = 6 \cdot 3$ mA; $g_{m1} = 2 \cdot 3$ mA/V;
$1/g_{m1} = 435\ \Omega$
$I_{a2} = 0 \cdot 5$ mA; $g_{m2} = 0 \cdot 46$ mA/V;
$\mu_2 = 16 \cdot 6$ $r_{a2} = 36$ kΩ

$$R_k = \frac{8 \cdot 5}{6 \cdot 8} = 1 \cdot 25 \text{ k}\Omega$$

$$\text{and } g_{m1} R_k \frac{\mu_1 + 1}{\mu_1} = 3$$

$$\text{giving } r = \frac{1 \cdot 25}{4} \text{ k}\Omega = 312\ \Omega$$

Hence from equation (8)

$$A = \frac{2 \cdot 3 \times 150 \times 0 \cdot 312 \times 17 \cdot 6}{33 + (17 \cdot 6 \times 0 \cdot 312) + 150}$$

$$= 10.$$

Figures obtained using the above method are compared with those obtained by Ross[1] in Table 2. The values of R_k and R_L are chosen arbitrarily from the table of results given in the above paper.

TABLE 2

R_L (kΩ)	R_k (Ω)	A due to Ross	A by equ. (8)
20	400	6·1	6·3
10	200	3·8	3·8
2	200	1·4	1·4

Bandwidth Restriction

An estimate of the capacitance shunting R_L having been made, and its reactance calculated at the upper limit of the band, the maximum permissible output impedance of the amplifier may be calculated. The amplifier is then designed with reference to R_{out} [equation (9)], rather than A, using a trial and error method. Grid bias is again the best independent variable and a start can be made with the near-optimum value found above. Since very exact results cannot be expected it should not be necessary to carry out the above procedure more than twice. The output impedances are, of course, very low and it is unlikely that this procedure will be required very often.

Harmonic Distortion

For large output voltages it is necessary, as usual, to plot the mutual characteristic for the anode load to be used. In such cases the output voltage is the main criterion, the gain taking second place. The required excitation is then calculated. In this case it may safely be assumed that the bulk of the distortion is generated in the second stage. A distortionless input to this stage may then be assumed. Again the arithmetical work is so simple and short that a trial and error method is satisfactory. Load resistance is the obvious independent variable.

The suggested method is perhaps best illustrated by means of examples, in which the second valve is considered as an isolated stage without feedback as follows:

$V_b = 250$ V; $R_L = 20$ kΩ

$v_{gmin} = -13$ V (for the minimum permissible anode current of about 0·5 mA).

$V_g = -7{\cdot}5$ V (minimum, fixed by anode dissipation in the first valve).

$v_g = 5{\cdot}5$ V (maximum effective excitation).

From the published curves and a dynamic load line for $R_L = 20$ kΩ we find:

Static $I_{a2} = 3{\cdot}20$ mA
Max. $I_{a2} = 6{\cdot}85$ mA
Min. $I_{a2} = 0{\cdot}40$ mA
$i_1 = 3{\cdot}22$ mA (fundamental)
$i_2 = 0{\cdot}21$ mA (second harmonic)

giving a second harmonic distortion of $D_{o2} =$ 6·5%

$V_{o1} = 3{\cdot}22 \times 20 = 64$ V.

If this process is repeated for a load resistance of 50 kΩ we find:

$R_L = 50$ kΩ	$I_{a1} = 10$ mA
$v_g = 4{\cdot}5$ V	$I_{a2} = 1{\cdot}65$ mA
$v_{o1} = 61{\cdot}5$ V	$R_k = 645$ Ω
$D_{o2} = 3{\cdot}25\%$	

For a load resistance of 200 kΩ the output voltage is down to 35 V with a distortion factor of 2·8%. Clearly, a load resistance of about 50 kΩ would give best results, a suitable reduction of excitation being made if the distortion is above limits. The required input to the amplifier may then be found with reasonable accuracy using equation (8) or, more accurately, by the method shown at the end of the next paragraph.

Effect of Feedback upon Harmonic Distortion

The feedback factor for the second stage is the only one which has any significance in this case.

For the load resistance of 50 kΩ we have:

$V_b = 250$ V; $R_L = 50$ kΩ; $V_g = -7{\cdot}5$ V

$I_{a1} = 10$ mA; $\mu_1 = 20$; $\therefore g_{m1} = 3{\cdot}0$ mA/V

and $I_{a2} = 1{\cdot}7$ mA; $\mu_2 = 17{\cdot}8$; $r_{a2} = 18{\cdot}6$ kΩ

$$R_k = \frac{7{\cdot}5}{11{\cdot}7}\ \text{k}\Omega = 640\ \Omega$$

giving $r = 213$ Ω (equation 4)

$$\therefore \beta_2 = \frac{213}{50} \times 10^{-3} = 4{\cdot}3 \times 10^{-3}$$

The gain of this stage without feedback is 13·7, giving a loop gain of $13{\cdot}7 \times 0{\cdot}0043 = 0{\cdot}06$

The distortion reduction factor is, therefore, 1·06, giving a resultant second harmonic content of 3%.

The overall gain may now be found more accurately as follows:

For the earthed-grid stage we have:

$$\text{gain without feedback} = \frac{61{\cdot}5}{4{\cdot}5} = 13{\cdot}7$$

$$\text{gain with feedback} = \frac{13{\cdot}7}{1{\cdot}06} = 13{\cdot}0$$

For the cathode-follower stage we have:

$I_{a1} = 10$ mA
$g_{m1} = 3{\cdot}0$ mA/V

$$\frac{1}{g_{m1}} = 333\ \Omega$$

$R_k = 645$ Ω

which gives an output/input voltage ratio of:

$$\frac{645}{645 + 333} = 0{\cdot}66.$$

Hence the overall gain is $13{\cdot}0 \times 0{\cdot}66 = 8{\cdot}6$.

The value of A found from equation (8) is 8·3, which for many purposes is sufficiently accurate. If no precise information about distortion is required then the gain may be calculated in this way without the necessity of evaluating β_2.

Conclusion

The theory has shown that the usual design methods for simple resistance-loaded voltage amplifier stages may be used for the cathode-coupled amplifier without any necessity for constructing special sets of curves. The accuracy obtained is of the same order, that is to say, sufficient to do justice to the valve tolerances. Extension to other types of cathode-coupled stages presents no difficulty.

REFERENCE

"Design of Cathode-Coupled Amplifiers", by S. G. F. Ross. *Wireless Engineer*, July 1950, Vol. 27, p. 212.

ABSTRACTS AND REFERENCES INDEX

The subject and author index to the abstracts and references published in *Wireless Engineer* during 1951 is now ready. It occupies 51 pages and includes a list of journals abstracted together with the publishers' addresses. Early application should be made to our Publisher for copies which cost 2s. 8d. including postage.

R.E.C.M.F.

The 1952 exhibition of components will be held from 7th to 9th April at Grosvenor House, Park Lane, London, W.1. Admission is restricted to holders of invitation cards from the Radio & Electronic Component Manufacturers Federation, 22 Surrey St., London, W.C.2.

APPLICATION OF COMMUNICATION THEORY

During September 1950, the subject of Information Theory was discussed at a Symposium held at the Royal Society. Arrangements are now being made for a further Symposium dealing with applications of this theory in the field of Telecommunications, to be held at the Institution of Electrical Engineers during the week commencing Monday, 22nd September, 1952. A preliminary programme of papers to be presented has been prepared, copies of which may be obtained from Professor Willis Jackson, Electrical Engineering Department, Imperial College, London, S.W.7.

NEW GRAPHICAL METHODS FOR ANALYSIS AND DESIGN

"Straight-Line" Representation of Filter Characteristics

by W. Saraga, Dr. Phil., and L. Fosgate

(*Telephone Manufacturing Co., Ltd.*)

SUMMARY—A new type of graphical method for filter analysis and design is developed. To start with, the concept of graphical 'straight-line methods' for the solution of network problems is introduced. Then the application of such methods to the analysis and design of image-parameter and insertion-parameter filters is described in some detail. The essential feature of these graphical methods is that the performance curve, usually a function of frequency, which is under consideration is transformed into a single straight line or into a sum of straight lines. In this way analysis and design work is in many cases considerably simplified, and it is thought that the underlying 'straight-line' concept could usefully be applied to the solution of other problems.

Introduction

GRAPHICAL methods are often used for the curve-approximating procedure which forms part of almost any network-design process. The user of such methods is interested in finding quickly the effect of variations of the values of design parameters on the performance characteristics of the network. Now any mathematical relation can be represented graphically in a number of different ways and the question of how to select the 'best' possible one in any given set of circumstances arises, therefore, as an important practical problem. In each particular case the ease or difficulty of using the method and of producing suitable graph paper, and also the accuracy obtainable, have to be considered. Furthermore, personal abilities, habits and preferences play an important part in the choice of a particular method. Therefore, it seems impossible to give definite rules for the selection of a graphical method without carrying out some kind of operational research into graphical analysis and design methods and the working habits of designers. In the absence of such operational research the selection of a graphical method must be guided by a mixture of past experience, rational analysis, and intuition. One 'guiding principle' which has arisen out of the practical work of the authors and some of their associates is a tendency to try to use, whenever possible, *straight lines* for representing the network performance curves which are under consideration.* The application of such 'straight-line' methods to a variety of filter problems will be described. As any straight line is determined by two parameters, only one- and two-parameter problems can be treated graphically by means of a single straight line†, and the extension to problems with more parameters will lead to the use of more than one straight line.

MS accepted by the Editor, March 1951

1. 'Straight-Line' Methods

Before discussing the concept of straight-line methods it is necessary to deal with a distinction between graphical methods for network analysis and design on the one hand, and graphical methods for pure computing problems on the other. This distinction can best be illustrated by means of a simple example. Let us consider the expression $|Z| = \sqrt{(R^2 + 4\pi^2L^2f^2)}$ where Z is the impedance of the series combination of an inductance L and a resistance R, and f is the frequency. If it is required to compute $|Z|$, we can regard $|Z|$ as a function of the three variables R, f, L, and a chart like that shown in Fig. 1(a) would be suitable for conveniently computing $|Z|$ for various values of the three variables.

In design and analysis, however, we are chiefly interested in $|Z|$ as a function of f, whereas R and L are parameters which, though variable, are constant for any particular $|Z|, f$ function under consideration. This means that it is desirable to show in a chart actual $|Z|, f$ curves. An example of such a chart which gives a number of such curves for various values of R and L is shown in Fig. 1 (b); the curves can be grouped in families, each family having a different value of R, and each curve within a family having a different value of L.

It is at this point that the concept of straight-line charts can conveniently be introduced. A designer of the R, L network under consideration would usually be interested in finding quickly how the $|Z|, f$ curves vary with variations of R and L, because he would have to approximate a specified required curve by means of the 'best' $|Z|, f$ curve.

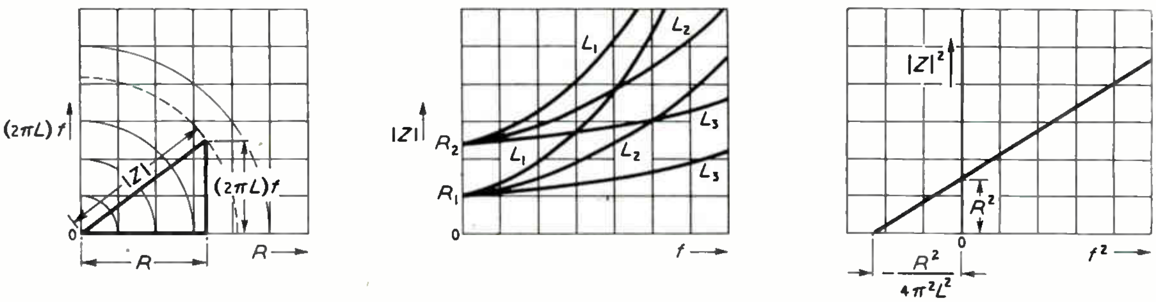
* This 'guiding principle' is in no way exclusive. In other network problems we have found it useful to represent the curve under consideration in a different way, namely by a single standard curve which is so chosen that a variation of the design parameters is represented by such modifications of this standard curve as displacements along the axes, multiplication of one or both of the scales by numerical factors, and shearing of the curve (for a discussion of both methods see Saraga[1]).

† Not all two-parameter curves can be represented as straight lines. In some cases it seems impossible to find a suitable transformation.

If in such a case a chart of the type shown in Fig. 1(b) is used, it is necessary to search among a great number of curves for the 'best' curve. This means that a great number of curves have to be computed and drawn beforehand, and it is difficult to decide on the optimum number of curves. If too few are drawn, not enough information is contained in the chart. If too many are drawn, it becomes difficult to identify individual curves and to keep them visually separate from adjacent curves. It is therefore usually impossible to avoid interpolation between adjacent curves and this is inaccurate.

$\sqrt{|Z|^2}$ and $f = \sqrt{f^2}$ for any given $|Z|^2, f^2$ point, it is much more convenient for the user of the chart, if functional scales for $|Z|$ and f are provided and if also the co-ordinate lines are drawn for selected $|Z|$ and f values, rather than for selected $|Z|^2$ and f^2 values. In problems with more than two parameters, where a number of straight lines have to be added together, the provision of functional scales and corresponding co-ordinate lines becomes absolutely essential.

The example of the R, L network has been used to introduce some of the ideas which lead to the development of straight-line methods. We can



(a) (b) (c)

Fig. 1. *Various graphical representations of the equation* $|Z| = \sqrt{(R^2 + 4\pi^2 L^2 f^2)}$

All these difficulties, in the preparation and in the use of the chart, can be avoided if the $|Z|, f$ curves shown in Fig. 1(b) can be transformed into straight lines. This is illustrated, for the particular example under consideration, in Fig. 1(c) in which the transformation of the $|Z|, f$ curves into straight lines has been achieved by replacing the original $|Z|, f$ co-ordinate system by a $|Z|^2, f^2$ system. In this new co-ordinate system the only computation required before a 'curve' can be drawn is the computation of the intercepts R^2 and $-R^2/(4\pi^2L^2)$ from any chosen parameter values R and L, and the drawing of the 'curve' can then be carried out by means of a straight edge without any plotting of individual points. Furthermore, there is no longer any need to plot a great number of 'curves' beforehand. As the drawing of a $|Z|, f$ curve for any particular set of R and L values is now so extremely simple, it is sufficient to prepare a suitable co-ordinate paper sheet and to draw any desired $|Z|, f$ curve when it is actually required. This means that in analysis problems we can now draw a $|Z|, f$ curve for any exact R and L values specified and that in design (i.e., in a curve approximation problem) we can draw the 'best' straight line to fit a required curve by direct visual inspection.

It would usually be desirable to be able to obtain Z and f values directly from any straight line 'curve' in the $|Z|^2$, f^2 system. Though this could be done by numerical evaluation of $|Z| =$

now try to state more formally the way in which we intend to approach any specific network problem in order to obtain a suitable straight-line method.

We are always interested in a particular network characteristic N as a function of an independent variable x (which in all cases discussed here is the normalized frequency); i.e., $N = F(x)$. This function contains a number of parameters and the design problem proper is to find the most suitable values of these parameters. We have then to distinguish two cases:

1. One- and two-parameter problems,
2. Problems with more than two parameters.

We shall deal with (1) first.

The basic idea of the straight-line method is to transform the N, x co-ordinate system into a w, z system which is so chosen that all N, x curves when plotted in the w, z system become straight lines, whatever parameter values are taken. The transformation of the system can be expressed by two functions, $z = \phi(x)$ and $w = \psi(N)$*.

For easier evaluation, in terms of N and x, of the straight lines in the w, z system, we shall provide functional scales for $N = \psi^{-1}(w)$ and $x = \phi^{-1}(z)$ along the w- and z-axes respectively, and we shall also provide co-ordinate lines based on these functional scales†.

* In some cases w is a function of N and x.

† When w is a function of N and x, then lines for equal N values are no longer parallels to the z-axis in the w, z system.

In problems with more than two parameters a straight-line representation is only possible if the network function $N(x)$, in a suitable co-ordinate system, can be split up into a sum of straight lines; i.e., a sum of one- or two-parameter curves. In this case, in order to simplify the addition of the straight lines, it is always necessary to provide a functional scale, and corresponding co-ordinate lines, for the particular variable in terms of which the addition of the straight lines has to be carried out.

Though in this article the application of this straight-line principle to filter problems only will be described, it is thought that in many other problems—not necessarily relating to networks—similar methods would be useful (as far as other network problems are concerned, see ref. 1 for an application to attenuation and phase-shift equalizer design and refs. 2, 3, 4 for applications to the design of networks with constant phase-shift difference).

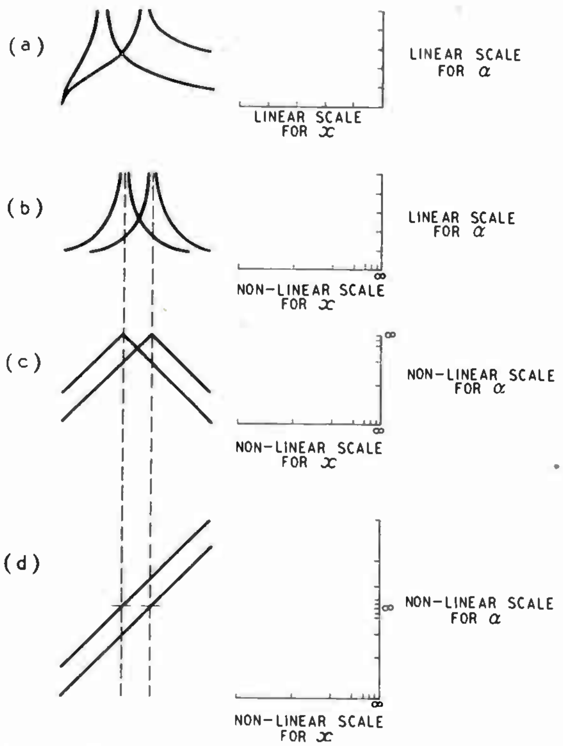


Fig. 2. *Development of a parallel straight-line representation of α as a function of x; where α is the image attenuation coefficient, and x is the normalized frequency. On the left side of the figure the transformation of the curves and on the right side the corresponding transformation of the scales is shown.*

2. Filter-Design Problems

Filters are usually designed so as to produce within specified tolerance limits a required insertion-loss/frequency characteristic. Classical design technique, due to Zobel, represents the insertion loss L as the sum of the image attenuation coefficient α, the two reflection losses L_R at the terminations and the interaction loss L_{int}. In the stop band we are going to make use of Zobel's representation and we shall be able to neglect L_{int}, which is very small in this band. In the pass band we are going to use a different representation of L, namely as function of the two image impedances Z_I and the image phase-shift coefficient β. Thus we shall need charts for α and L_R in the stop band, and for Z_I and β in the pass band.

In the modern insertion parameter approach to filter design and analysis L is represented as a direct function of the frequency f, without being split up into various loss components and without the introduction of the image parameters as an intermediate step in establishing the relation between L and f. This approach leads in *design* work to filters of a more general type than those based on Zobel's image parameter technique. However, in *analysis* problems the direct evaluation of the insertion loss can be applied to Zobel filters as well as to more general insertion parameter filters. A straight-line chart for the representation and evaluation of the insertion loss of some types of Zobel and non-Zobel filters will be described.

3. Image Attenuation Coefficient α of Multi-Section Zobel Filters

The image attenuation coefficient α, as a function of the frequency f, of a multi-section Zobel filter can be found as the sum of the α, f curves of the individual sections. Because of this simple relation and because the α, f curve is a rough guide to the insertion-loss curve of the filter in the stop band, the α, f curve is usually used as the basis of the design of these filters. Classical filter theory shows that for an m-derived single low-pass* filter section with cut-off frequency f_0 the image-attenuation coefficient α (in nepers) is given by

$$\left.\begin{array}{l}(\tanh \tfrac{1}{2}\alpha)^{\mp 1} = m\,(1 - x^{-2})^{-\frac{1}{2}} \\ \text{for } x = {1 \ldots a \atop a \ldots \infty}\end{array}\right\} \quad \ldots \quad \ldots \quad (1)$$

where $x = f/f_0$ and m is a constant with any value between 0 and + 1; instead of m the parameter $a = (1 - m^2)^{-\frac{1}{2}}$ is often used. Two α, x curves for different values of a are shown schematically in Fig. 2 (a). Two disadvantages of this representation can be seen:—

1. A great number of curves for different values of a has to be plotted if interpolation, which for this chart is rather difficult, is to be avoided.

* The results of this discussion can also, in the usual way, be applied to high-pass, band-pass and band-stop filters (see Appendix).

2. The shape of each curve is different so that the preparation of such a chart requires a great amount of work.

These disadvantages can be overcome by a suitable transformation of equation (1) from the α, x to a suitably chosen w, z system. Three new equations can be obtained, all of them—in different ways—expressing the same relation between α and x as equation (1). They are listed below as equations (2), (3a) and (3b):—

$$\left.\begin{aligned} &w = m^{-q}z, \\ &\text{where } q \text{ is an arbitrary real number,} \\ &z = [(1 - x^{-2})^{+\frac{1}{2}}]^q \text{ and} \\ &w = [(\tanh \tfrac{1}{2}\alpha)^{\pm 1}]^q \text{ for } x = \begin{matrix} 1 \ldots a \\ a \ldots \infty \end{matrix},\ z = \begin{matrix} 0 \ldots m^q \\ m^q \ldots 1 \end{matrix} \end{aligned}\right\} \quad \ldots (2)$$

$$\left.\begin{aligned} w &= 2 \tanh^{-1}\{\exp [\pm (z - M)]\} \\ &= -\log_e \tanh [\mp \tfrac{1}{2} (z - M)] \\ &\text{for } x = \begin{matrix} 1 \ldots a \\ a \ldots \infty \end{matrix},\ z = \begin{matrix} -\infty \ldots M \\ M \ldots 0 \end{matrix} \\ &\text{where } w = \alpha,\ z = \tfrac{1}{2}\log(1 - x^{-2}),\ M = \log m \end{aligned}\right\} \quad \ldots (3a)$$

$$\left.\begin{aligned} &w = \pm (z - M) \text{ for } x = \begin{matrix} 1 \ldots a \\ a \ldots \infty \end{matrix},\ z = \begin{matrix} -\infty \ldots M \\ M \ldots 0 \end{matrix} \\ &\text{where } w = \log \tanh \tfrac{1}{2}\alpha;\ z \text{ and } M \text{ as in (3a).} \end{aligned}\right\} \quad \ldots (3b)$$

Equations (2), (3a) and (3b) can be easily verified by substituting for w, z and M in accordance with the definitions given. Equation (2) leads to a straight-line ray chart in the w, z system, since for any value of m the corresponding α, x curve in the w, z system is a straight line through the origin, with slope m^{-q}. Fig. 3 shows schematically a chart based on equation (2). q was chosen as $\frac{4}{3}$ because it was found that this value gives convenient scales for α and x. Three lines corresponding to sections with different a-values are shown.

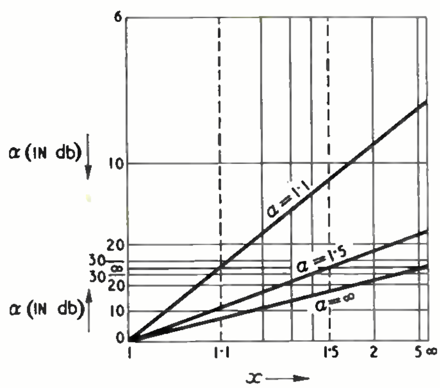


Fig. 3. *Schematic illustration of a straight-line ray chart for α as a function of x.*

Equation (3b) leads to a parallel-line chart. This equation in the slightly different form given in (3a) has been used before by Laurent[5] and Rumpelt[6] for developing a template method. The parallel-line chart method can best be explained as a further development of this template method; the template method will therefore be described first.

Equation (3a) shows that in the α, z co-ordinate system the shape of the curves given originally by (1) is independent of the particular value of m (or a) which determines only the position of the curve along the abscissa axis. Therefore it is not necessary to draw a great number of curves for different a-values nor to interpolate between them. It is sufficient to draw a single standard curve and to obtain the curves for any a-value when actually required by shifting the standard curve or template into a position corresponding to the required a-value. This is shown schematically in Fig. 2(b). In practice a template is usually used. A detailed description of this method is given by Scowen.[7]*

The development of a straight-line method from the template method will now be described. In Fig. 2 (b) we have a linear α-scale. If we replace it by a suitable non-linear scale for α which is identical with introducing a linear scale for $w = \frac{1}{2} \log \tanh z$ [see equation (3b)], we can replace the template curve of Fig. 2(b) by a pair of straight lines as illustrated in Fig. 2 (c).†

This method can be further modified by adding to the original system a mirror image of the co-ordinate system about the abscissa axis. It will be seen from Fig. 2 (d) that the original pair of straight lines can then be replaced by a single straight line consisting of one of the original lines and the mirror image of the other. A simplified version of an actual chart of this kind is shown in Fig. 4.‡ All straight lines, for any value of a, have the same slope, and for a particular value of a the corresponding line has to cross the abscissa axis (i.e., the line $\alpha = \infty$) at $x = a$. The auxiliary x-axis is provided in order to simplify the drawing of the straight lines with the correct slope $+1$. The purpose of the imaginary x-scale will be shown in the Appendix. A practical example of the use of this chart will be given in Section 9.

At this point it seems appropriate to compare

* Scowen does not give an explicit scale for x, but a logarithmic scale for $X = 1 - x^{-2}$.

† Recently Rowlands[2] has described a similar case of a performance characteristic expressed by means of a pair of straight lines in conjunction with a functional scale for the ordinate axis. See also letter by Saraga[3].

‡ It is not possible in this article to reproduce the actual charts which we use, as they are large and detailed. Their sizes vary from about 10 in. × 10 in. to 20 in. × 20 in.

the straight-line methods suggested here with the template or standard curve method proposed by previous writers. As stated above, such comparisons are bound to be subjective, but in spite of this some advantages and disadvantages of the two methods may be mentioned. The drawing of straight lines is simpler than the drawing of curves by means of templates or by tracing standard curves on to transparent paper. Also the chances of inaccurate drawing are greater if a template or standard curve has to be held in position than if a straight line has to be drawn through two points. Furthermore, it seems that a method which needs only straight edges as tools is preferable to one using standard curves or templates. On the other hand, some users of templates point out that they prefer template methods when a summation of curves is required because a linear scale can then be used for the ordinate axis and the addition can be carried out by means of dividers (we do it numerically, preferably by transferring the values from the chart directly to the calculating machine).

As far as a comparison between the parallel straight-line method and the ray straight-line method is concerned, we have no preference in principle, but in the particular problem under consideration, the representation of the α, x curve, we prefer the parallel-line chart, because it is symmetrical about the line $\alpha = \alpha$, whereas the ray chart is not, and in this case needs a larger size to give the same accuracy.

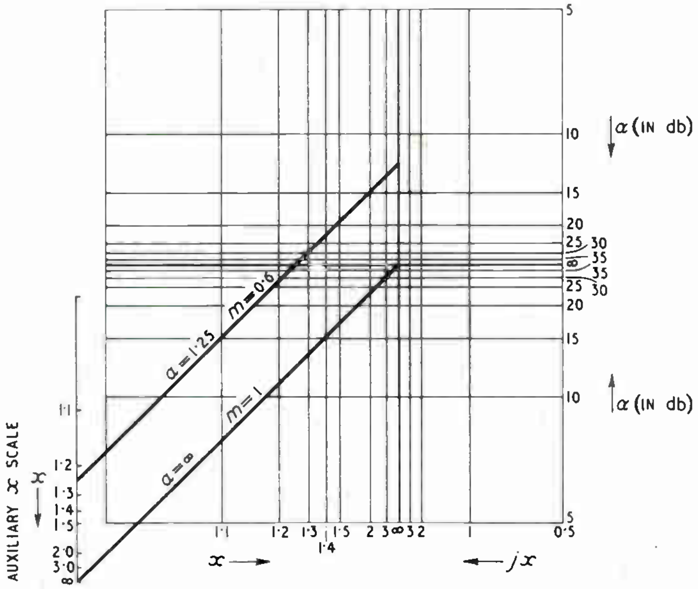


Fig. 4. *Simplified version of a parallel straight-line chart for the image attenuation coefficient α as a function of x.*

4. Image Phase-Shift Coefficient β of Multi-Section Zobel Filters

A graphical representation of the relation between β and x for a single section can be obtained in the same way as in the case of the image-attenuation coefficient α. β as a function of x is given by

$$\tan \tfrac{1}{2}\beta = m\,(x^{-2} - 1)^{-\frac{1}{2}},\ x = 0 \ldots 1 \quad .. \quad (4)$$

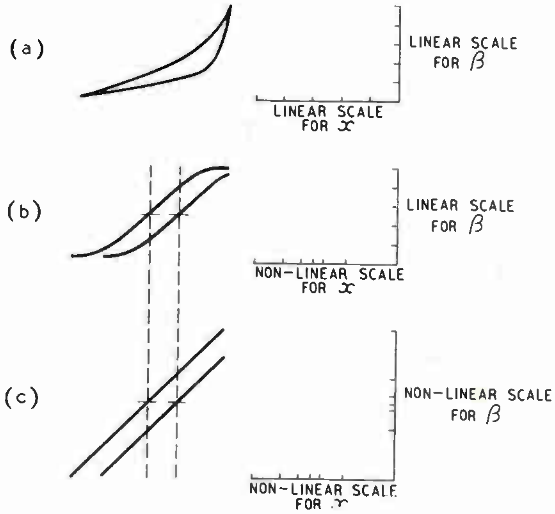


Fig. 5. *Development of a parallel straight-line representation of β as a function of x; where β is the image phase-shift coefficient, and x is the normalized frequency. On the left side of the figure the transformation of the curves and on the right side the corresponding transformation of the scales is shown.*

Two typical curves for different m-values are shown in Fig. 5 (a). Equation (4) can be rewritten in the form

$$w = z - M \quad .. \quad .. \quad (5)$$

where $w = \log \cot \frac{1}{2}\beta$, $z = \frac{1}{2}\log(x^{-2} - 1)$, $M = \log m$.

If linear scales for β and z (i.e., a non-linear scale for x) are used, we arrive at the template representation illustrated in Fig. 5 (b) which, as in the case of the α, x template method, is due to Laurent and Rumpelt and is described by Scowen. If we use a suitable functional scale for β (linear for $w = \log \cot \frac{1}{2}\beta$) we obtain a straight-line representation with parallel lines as indicated in Fig. 5 (c). Each straight line intersects the line $\beta = \pi/2$ at $x = b = (1 + m^2)^{-\frac{1}{2}} = (2 - a^{-2})^{-\frac{1}{2}}$. Fig. 6 shows a simplified version of a chart of this kind.* The total image phase-shift coefficient of a

A corresponding ray chart can also easily be obtained multi-section filter is found as the sum of a number of straight lines. In some cases it is possible to obtain an approximation to the total image phase-shift coefficient by drawing a single straight line corresponding to a suitably chosen compromise m-value.

5. Reflection Loss in the Stop Band

In the stop band of a filter the insertion loss L is equal to the sum of the image attenuation coefficient α and the two reflection loss components L_R occurring at the two junctions of the filter and its terminating resistances (if the source resistance is not equal to the load resistance, a constant gain term has to be subtracted from the sum $\alpha + (L_R)_1 + (L_R)_2$ in order to obtain L).

The reflection loss occurring at the junction of a terminating resistance R_T and an image impedance Z_I of an m-derived filter section depends on two parameters, the a-value of this section and the ratio R_0/R_T where R_0 is the design impedance; i.e., the value of Z_I at $x = 0$. Therefore a representation of the L_R, x curves as straight lines, for any values of m and R_0/R_T, may be possible. We shall now show that such a representation is indeed possible.

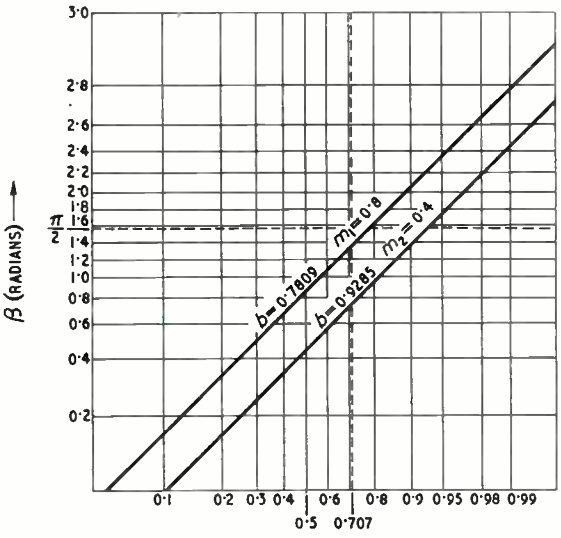


Fig. 6. *Simplified version of a parallel straight-line chart for image phase-shift coefficient β as a function of x.*

The reflection loss is given by the formula

$$L_R = 20 \log_{10} \left| \tfrac{1}{2} \left(\sqrt{Z_I/R_T} + \sqrt{R_T/Z_I} \right) \right| \quad \ldots \quad (6a)$$

As in the stop band of a filter the image impedance is purely reactive (neglecting dissipation), $Z_I = jX_I$ say, we obtain from (6a)

$$L_R = 10 \log_{10} \left| \tfrac{1}{4} (X_I/R_T + R_T/X_I) \right| \quad \ldots \quad (6b)$$

i.e., L_R is a symmetrical function of X_I/R_T and R_T/X_I. We have to consider the four terminating half-sections shown in Fig. 7. However, the half-sections shown in Fig. 7 (a) and (c) can be regarded as special cases of those in Fig. 7 (b) and

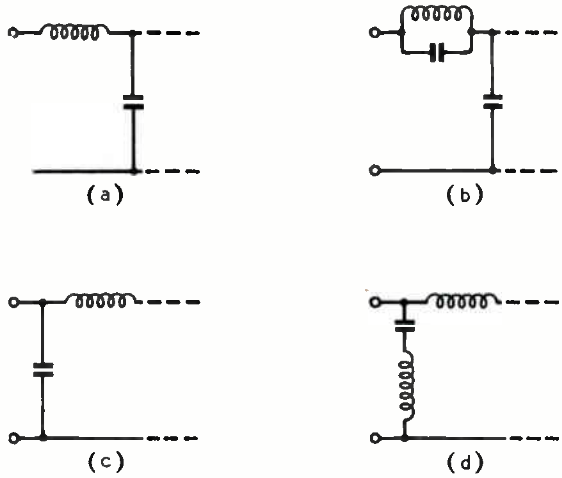


Fig. 7. *Four types of terminating half-section.*

(d) respectively, with $a = \infty$. Therefore only two different cases remain for final consideration, and we obtain for Fig. 7 (b)

$$X_I/R_T = (R_0/R_T)\, a^2 (x^2 - 1)^{\frac{1}{2}}/(a^2 - x^2) \quad \ldots \quad (7a)$$

and for Fig. 7 (d)

$$X_I/R_T = -(R_0/R_T)\,(a^2 - x^2)/[a^2(x^2 - 1)^{\frac{1}{2}}] \quad \ldots \quad (7b)$$

If we introduce a parameter r and define it as R_0/R_T for Fig. 7 (b) and as R_T/R_0 for Fig. 7 (d), X_I/R_T for Fig. 7 (d) becomes the reciprocal of X_I/R_T for Fig. 7 (b) apart from the sign which is irrelevant. In view of the fact that L_R is symmetrical with regard to X_I/R_T and its reciprocal, it is sufficient to discuss only the expression given in (7a). To transform (7a) into an equation corresponding to a straight line we introduce two new variables,

$$z = x^2 \text{ and } w = (R_T/X_I)\,(x^2 - 1)^{\frac{1}{2}} \quad \ldots \quad (8a)$$

Then (7a) becomes

$$\frac{w}{1/r} + \frac{z}{a^2} = 1 \quad \ldots \quad (8b)$$

which is the equation of a straight line in the w, z system with intercepts $1/r$ on the w-axis and a^2 on the z-axis. However, as the new dependent variable w is not—as in all previous cases discussed here—a function of the original dependent variable, viz. X_I/R_T only, but also of x, the lines of equal X_I/R_T are not identical with the lines of equal w which are parallels to the z-axis. It will be seen (from 8a) that the lines of equal X_I/R_T are parabolae given by $w = (R_T/X_I)\,(z - 1)^{\frac{1}{2}}$. If

* For choice of compromise values see, e.g., Saraga and Freeman.[8]

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these parabolae are labelled, not with their (X_I/R_T)-values, but with the corresponding L_R-values, we obtain a chart of the kind shown in Fig. 8. It will be seen that the two limiting curves, namely the line $z = 1$ and the positive z-axis are labelled $L_R = +\infty$. The reflection loss varies from $+\infty$ to $-3{\cdot}01$ db and back to $+\infty$. The scales have been so chosen that the loss-range between $+\infty$ and 0 near the w-axis is compressed and the remainder of the range (viz., from 0 via $-3{\cdot}01$ db to 0 and $+\infty$) is opened up because this range is of greater practical use. For convenience the scale along the w-axis is marked in $1/r$. A practical example in which this chart is used will be discussed in Section 9.

6. Image-Impedance Chart for the Pass Band

We shall only consider two types of filters: (1) filters with equal image impedances Z_I between equal terminating resistances R_T, and (2) filters with image impedances Z_I and R_o^2/Z_I between terminating resistances R_T and R_o^2/R_T. In the first case the insertion loss is

$$L = L_1 = 10 \log_{10} [1 + \tfrac{1}{4} (Z_I/R_T - R_T/Z_I)^2 \sin^2\beta] \quad \ldots \quad (9a)$$

and in the second case, apart from a constant term $L_o = -20 \log_{10} [\tfrac{1}{2}(R_T/R_o + R_o/R_T)]$ (if the terminating resistances are unequal),

$$L = L_2 = 10 \log_{10} [1 + \tfrac{1}{4} (Z_I/R_T - R_T/Z_I)^2 \cos^2\beta] \quad \ldots \quad (9b)$$

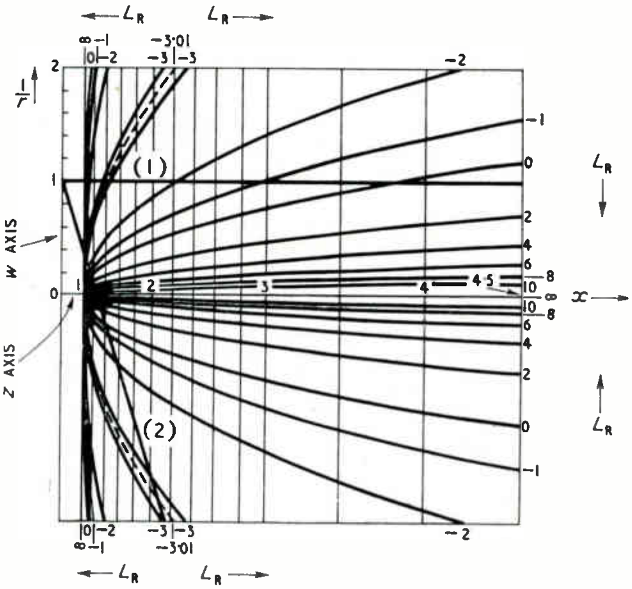

Fig. 8. *Simplified version of a reflection loss chart.*

It will be seen that both for (9a) and (9b)

$$L \leqslant L_{env} = 10 \log_{10} [1 + \tfrac{1}{4}(Z_I/R_T - R_T/Z_I)^2]$$

$= 20 \log_{10} [\tfrac{1}{2} (Z_I/R_T + R_T/Z_I)]$ where L_{env} represents the envelope curve for the insertion loss in the pass band (see Belevitch)[9]. We have* $L_1 = 0$ and $L_2 = L_{env}$, when $\beta = 0, \pi, 2\pi \ldots$, and $L_1 = L_{env}$, $L_2 = 0$, when $\beta = \tfrac{1}{2}\pi$, $3\pi/2, \ldots$ Thus the chart for β described in Section 4 together with a chart for L_{env} which will be described in this section will enable us to plot the insertion loss of composite Zobel filters in the pass band.

In the pass band Z_I/R_T is real, viz.:—

$$\frac{Z_I}{R_T} = \left[\frac{ra^2 (1 - x^2)^{\frac{1}{2}}}{a^2 - x^2}\right]^{\pm 1} \quad \ldots \quad \ldots \quad (10a)$$

where r is defined as before. With $w = (1 - x^2)^{\frac{1}{2}} R_T/X_I$ and $z = x^2$ we obtain from (10a) a straight-line representation of Z_I/R_T, namely

$$\frac{w}{1/r} + \frac{z}{a^2} = 1 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (10b)$$

The lines of equal R_T/Z_I in the w, z system are parabolae given by $w = (R_T/Z_I)(1 - z)^{\frac{1}{2}}$. These lines can be labelled with the corresponding L_{env}-values. This chart is not shown here as it is very similar to the L_R chart shown in Fig. 8.

7. Direct Computation of Insertion Loss

In this section we shall consider the graphical determination of the insertion loss of image parameter as well as of more general filters (insertion parameter filters, see, e.g., Darlington[10]). The chart developed for this purpose can also be used for design purposes. This will be the subject of the next section

The insertion-loss chart in the form to be described here has been developed for symmetrical filters (filters with equal image impedances). The discussion will be restricted to such filters, as this is sufficient to show the principle of this application of straight-line methods. For symmetrical low-pass filters the insertion loss L (in db) can be written in the form $L = 10 \log_{10} (1 + E^2)$, where E is an odd rational function of x; i.e., of the form $E = HxP(x^2)/Q(x^2)$ where H is a real constant and $P(x^2)$ and $Q(x^2)$ are polynomials in x^2, of equal degree and with real coefficients. We can therefore write E in the form

$$E = Hx \frac{(x^2 - x_1^2)(x^2 - x_2^2) \ldots (x^2 - x_k^2)}{(x^2 - a_1^2)(x^2 - a_2^2) \ldots (x^2 - a_k^2)} \quad \ldots \quad \ldots \quad \ldots \quad (11a)$$

* This statement is *not* valid at the cut-off frequency.

i.e., the $x_1^2, x_2^2, \ldots x_k^2$ are the roots of $P(x^2)$ and the $a_1^2, a_2^2, \ldots a_k^2$ are the roots of $Q(x^2)$. We shall, to start with, assume that all x_i^2 and all a_i^2 are real and positive. Later on we shall also discuss the cases in which some of the x_i^2 are zero or negative, or some of the a_i^2 are infinite (in which latter case the degree of the denominator is reduced).

In order to obtain a straight-line representation for (11a) we shall rewrite it in the form

$$\frac{E}{x} = H' \frac{\left[\frac{1}{2}\left(\frac{x}{x_1} - \frac{x_1}{x}\right)\right] \cdots}{\left[\frac{1}{2}\left(\frac{x}{a_1} - \frac{a_1}{x}\right)\right] \cdots},$$

where $H' = H \dfrac{x_1 x_2 \ldots \ldots x_k}{a_1 a_2 \ldots \ldots a_k}$, and finally in the form

$$\log|E/x| = \log H' + \sum_{i=1}^{k} \log|\sinh (z - z_{1i})| - \sum_{i=1}^{k} \log|\sinh (z - z_{2i})| \qquad \ldots (11b)$$

where $z = \log_e x$, $z_{1i} = \log_e x_i$ and $z_{2i} = \log_e a_i$*. Equation (11b) can be used as the basis of a template or standard-curve method for computing $\log|E/x|$, and this method can be transformed into a straight-line method, in a way similar to that discussed for the α, x chart. $\text{Log}|E/x|$ is obtained as the sum and difference of a suitably chosen constant $\log H'$, and a number of standard curves $\log|\sinh z|$ shifted along the z-axis by suitably chosen amounts z_{1i} or z_{2i}. The disadvantage of a chart of this type is that subtraction leads to a loss of accuracy, and so the chart has to be drawn with more lines and used with more care than would otherwise be the case. However, it does not seem to be possible to find a graphical representation for (11a) which avoids subtraction and does not at the same time introduce some other and greater disadvantage. Therefore (11b) has been chosen as the basis of the straight-line method to be described.

Fig. 9 (a) shows schematically two standard curves $\log|\sinh z|$ which are shifted by different amounts along the z-axis. Fig. 9 (b) shows the replacement of these curves, which in Fig. 9 (a) are plotted against a linear ordinate scale (p-scale), by pairs of straight lines plotted against a functional p-scale (which is linear for $w = \sinh^{-1}(e^p)$). Finally Fig. 9 (c) shows the addition of a mirror image to the co-ordinate system which makes it possible—as in the case of Fig. 2 (c) and (d)—to replace each pair of straight lines by a single straight line with unit slope.

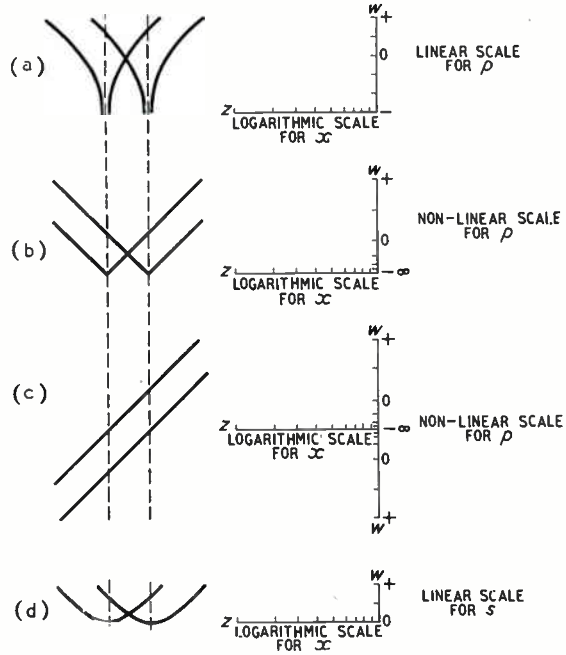

Fig. 9. *Development of an insertion-loss chart. On the left side of the figure the transformation of the curves and on the right side the corresponding transformation of the p-scale on the w-axis and the x-scale on the z-axis are shown. (a), (b) and (c) show the parallel straight-line representation of log | sinh z| as a function of z, while (d) illustrates the template representation of log cosh z as a function of z.*

A simplified version of a chart based on these ideas is shown in Fig. 10.† The abscissa axis of this chart is the x-axis which has a logarithmic scale (at the bottom of the chart). There are two ordinate axes, a ($\log|E/x|$)-axis and a p-axis. There are therefore two ordinate scales, a linear scale for $\log|E/x|$, marked along the line $x = 1$, and a functional scale for p, marked along the line $x = 10$; i.e., on the right-hand side of the chart. The standard curves $\log|\sinh z|$ are straight lines with slope $+ 1$ (the slope being referred to the abscissa unit $\log_{10} x = 1$ and the ordinate unit $\log_{10}|E/x| = 1$). Four of these lines, numbered (1), (2), (3), (4), are shown in the chart; they refer to the example discussed in Section 9.

The p-scale is intended for reading off the values of the individual $\log|\sinh z|$ curves. Their sum is plotted against the $\log|E/x|$ scale. In order to obtain from $\log |E/x|$ the insertion loss

* A different way to obtain a straight-line representation of (11a) would be to represent each term $x^2 - x_i^2$ or $x^2 - a_i^2$ in a w, x^2 system as a straight line with unit slope and intercept x_i^2 or a_i^2 on the x^2 - axis. E/x would then be obtained as the quotient of two products of straight lines. However, a linear scale for x^2 leads to crowding near the origin, and an E/x scale which is suitable for the pass band of a filter is usually not suitable for the stop band, and vice versa. Furthermore, multiplication and division are operations which in graphical methods should, as far as possible, be replaced by addition and subtraction. Therefore the straight-line representation based on equation (11b) has been chosen.

† In this chart $\sinh z = \frac{1}{2}(e^z - e^{-z})$ is, for convenience, replaced by $\frac{1}{2}(10^z - 10^{-z})$ which may be written as $\sinh_{10} z$, and all logarithms are taken to the base 10.

L we need also a scale for L and lines for equal L-values. As the lines for equal log $|E/x|$ are parallels to the abscissa axis and this axis is linear for $z = \log x$, the lines for equal log E, which are also lines for equal L, become straight lines with slope -1. Such lines, labelled with the corresponding L-values, have been drawn in (see the scale at the left and at the top of the chart), and therefore the plotting of the log$|E/x|$ curve gives immediately, without any further work, the desired insertion-loss curve. A practical example of the use of this chart will be described in Section 9.

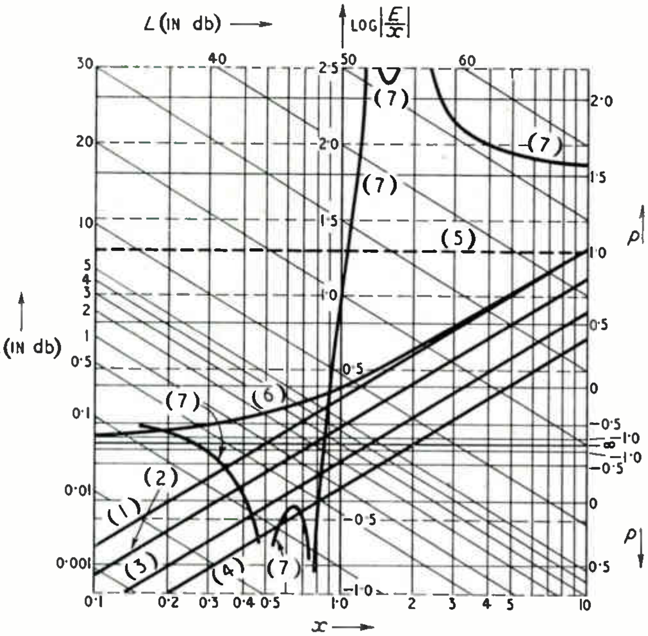

Fig. 10. *Simplified version of a parallel straight-line insertion loss chart.*

It was mentioned before that in equation (11a) some x_i^2 may be zero. Then the log$|\sinh z|$ curves alone—or the straight lines corresponding to these curves—are not sufficient for the graphical representation of log$|E/x|$. This will will be shown for the case $x_1^2 = 0$. Then we obtain from (11a)

$$E = Hx \frac{x^2 (x^2 - x_2^2) \ldots (x^2 - x_k^2)}{(x^2 - a_1^2)(x^2 - a_2^2) \ldots (x^2 - a_k^2)}$$

and

$$\log|E/x| = \log(H'') + \log x + \sum_{i=2}^{k} \log|\sinh(z - z_{1i})|$$
$$- \sum_{i=1}^{k} \log|\sinh(z - z_{2i})| \quad \ldots \quad \ldots \quad (11c)$$

where $H'' = \dfrac{Hx_2 \ldots x_k}{2a_1 a_2 \ldots a_k}$.

(11c) shows that in the case of one x_i being zero we need for the graphical representation of log$|E/x|$, in addition to the curves log$|\sinh(z - z_{1i})|$ and log$|\sinh(z - z_{2i})|$ a fixed curve log x. If 2, 3, . . . or k of the x_i are zero, we need (2, 3, . . .k) log x. Therefore it is necessary to have the curve log x permanently drawn in the chart. Against the log$|E/x|$ ordinate scale this curve would be a straight line. However, against the functional p-scale log x becomes a curve* [see curve (6) in the chart].

We shall next consider the case of some or all of the a_i becoming infinite (this happens, for instance, if the given filter consists of constant-k sections only). It is sufficient to discuss the case $a_1 \to \infty$. Then (11a) degenerates to

$$E = \frac{H}{a_1^2} x \frac{(x^2 - x_1^2)(x^2 - x_2^2) \ldots (x^2 - x_k^2)}{(x^2 - a_2^2) \ldots (x^2 - a_k^2)}$$

where $H/a_1^2 \neq 0$. Then

$$\log|E/x| = \log\left(\frac{2H}{a_1^2} \frac{x_1 x_2 \ldots x_k}{a_2 \ldots a_k}\right) + \log x$$
$$+ \sum_{i=1}^{k} \log|\sinh(z - z_{1i})|$$
$$- \sum_{i=2}^{k} \log|\sinh(z - z_{2i})| \quad \ldots \quad (11d)$$

Equation (11d) is of the same form as (11c) and can therefore be treated in the same way; i.e., by making use of the log x curve in the chart.

The last special case which will be discussed here is that in which some of the x_i^2 are negative, say $x_i^2 = -y_i^2$, $y_i^2 > 0$. Then we can separate from (11a) factors of the form $(x^2 + y_i^2)/2x$ which can be transformed into $y_i \frac{1}{2}(x/y_i + y_i/x) = y_i \cosh(z - z_{1i})$ where $z = \log_e x$ and $z_{1i} = \log_e y_i$. The term $(x^2 + y_i^2)/2x$ can therefore be represented in the co-ordinate system of Fig. 9 (a) as a log cosh z curve shifted along the z-axis by an amount z_i. Thus templates for the curve $s = \log\cosh z$ could be used [see Fig. 9 (d)], together with templates for the log$|\sinh z|$ curve, in the co-ordinate system of Fig. 9 (a). However, in order to transform the log cosh z curve and the log$|\sinh z|$ curve into straight lines, two different functional scales for the ordinate axis would be required, and therefore in such a case a template method would be preferable.

* It would, of course, be possible to use this log x curve also in the general, non-degenerate, case in which only one term x appears in (11a). Then the scale for log$|E/x|$ which has been drawn at $x = 1$ would become a scale for log$|E|$, or, if properly labelled, for L, and the lines for equal L would become parallels to the abscissa axis. Then, however, three sets of parallels to the abscissa axis would be superimposed on each other, and this would make the use of the chart more difficult.

8. Design of Insertion-Parameter Filters

In this section we shall discuss the use of the chart shown in Fig. 10 for design purposes. All other charts discussed in this article can equally well be used for the analysis of given filters and for the design of required filters. In the case of the chart shown in Fig. 10 the situation is different. The analysis of symmetrical image-parameter filters shows that the zeros and poles of E and the constant H cannot be chosen independently if the filter consists of more than a single section.* Now in the case of visual curve fitting the design parameters are so chosen as to obtain the best possible approximation to a required curve, without any regard to any necessary relations between the design parameters. Therefore it is not possible to use the chart shown in Fig. 10 for the design of image-parameter filters by direct visual curve fitting. If, however, it is not required to restrict the design to image-parameter filters, then all design parameters (i.e., all x_i, all a_i and H) can be chosen freely, and the chart shown in Fig. 10 is suitable for design purposes. In this case, after a set of suitable values for the design parameters has been found, a corresponding filter network has to be synthesized. Methods of synthesis are well known (see, e.g., reference 10).

It is interesting to compare the design of an image-parameter filter by means of the α, x chart shown in Fig. 4 with that of an insertion-parameter filter by means of the L, x chart shown in Fig. 10. If we consider a two-section filter, E is of the form $E = Hx\dfrac{(x^2 - x_1^2)(x^2 - x_2^2)}{(x^2 - a_1^2)(x^2 - a_2^2)}$. In the α, x chart two straight lines, corresponding to a_1 and a_2, have to be added. In the L, x chart four straight lines corresponding to x_1, x_2 and a_1, a_2 have to be summed in accordance with equation (11b). Thus it may be said that the use of the L, x chart requires roughly twice as much work as the use of the α, x chart and it also necessitates the use of subtraction with the accompanying disadvantages mentioned before. For the price of this greater effort we are able to compute directly the insertion loss in the pass band, the stop band and the transition range between these bands, whereas the α, x chart gives information concerning the stop band only. Furthermore it would be necessary to use, in addition, the L_R, x chart in order to obtain L rather than α.

* For a two-section image parameter filter with design impedance R_o, cut-off frequency f_o, and m-values m_1 and m_2, inserted between equal terminating resistances R_T, it can be shown [11] that E as a function of the frequency f is given by $E = Hf\dfrac{(f^2 - f_1^2)(f^2 - f_2^2)}{(f^2 - f_{\infty 1}^2)(f^2 - f_{\infty 2}^2)}$ where $H = (R_o/R_T)a_1^2a_2^2(1 + m_1m_2)(m_1 + m_2)f_o$, $f_1^2 = f_o^2[1 - (R_T/R_o)^2]$, $f_2^2 = f_o^2(1 + m_1m_2)$, $f_{\infty 1}^2 = f_o^2 a_1^2$, $f_{\infty 2}^2 = f_o^2 a_2^2$. It will be seen that, when $f_1, f_2, f_{\infty 1}, f_{\infty 2}$ have been chosen, f_o, R_o/R_T, m_1, m_2 are determined and H can therefore no longer be freely chosen.

However, it is possible to design insertion-parameter filters without this doubling of effort if we restrict the curve-fitting procedure to the stop band and are satisfied, as far as the pass band is concerned, with specifying only the general character of the loss curve. For instance, the pass-band curve may be oscillatory as illustrated in Fig. 11 (a) or smoothly increasing as shown in Fig. 11 (b). Filters with this oscillatory pass-band performance can be designed by means of the 'reference-filter' method. This method, which makes use of an α, x chart for obtaining the desired stop-band performance, is well known[10] and will therefore not be discussed here.

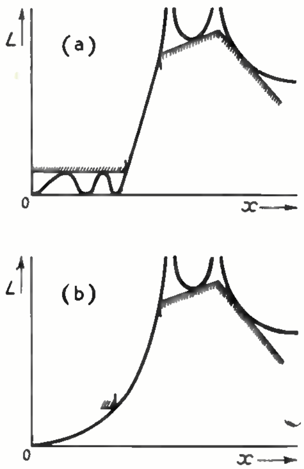

Fig. 11. *Filter insertion loss curves; (a) shows the Tchebycheff approximation to zero loss in the pass band, and (b) the Taylor approximation to zero loss in the pass band.*

Filters with a smoothly-increasing loss curve in the pass band and approximating an arbitrary specified loss curve in the stop band have not been treated in the literature and it is therefore of interest to note that they can be designed by means of the L, x chart shown in Fig. 10. This will now be briefly discussed. We have to choose an E, x function of the form

$$E = Hx\frac{x^{2k}}{(x^2 - a_1^2)(x^2 - a_2^2)\ldots(x^2 - a_k^2)}$$

i.e., we have to make all x_i equal to zero. Then $\log|E/x|$, and therefore L, is determined (apart from a suitable constant $\log[H/(2^k a_1 a_2 \ldots a_k)]$) by the difference of $k \log x$ (i.e., k times the values read off curve (6)) and the sum of k straight lines with slope $+1$ drawn for suitable values $a_1, a_2, \ldots a_k$.

9. Two Practical Examples

Two examples of applying the graphical methods discussed above will be given. As the emphasis in these examples is on the graphical methods used, and not on the filter problem, in one case only part of the filter performance curve under discussion will be evaluated. In both examples the insertion loss of a low-pass filter is obtained graphically. In the first example Zobel's technique of splitting up the insertion loss into various components is used, and only the stop band will be considered. Thus the insertion loss can be found as the sum of the image attenuation coefficient and the two reflection losses. In the second example the insertion loss is known as an analytic function of the frequency (actually the filter was designed to have an insertion loss in accordance with this specific function), and graphical methods will be used for evaluating this function numerically. In order to demonstrate the characteristic features of the various graphical methods as clearly as possible, it has been found convenient to choose different filters for the two examples.

Example 1. The stop-band loss of the Zobel type low-pass filter shown in Fig. 12 (a) will be evaluated (neglecting dissipation). The filter has $1\frac{1}{2}$ sections; viz., a constant-k section and a half-section with $a = 1{\cdot}25$. The source and load resistances are assumed to be equal to each other and equal to the design impedance of the filter; i.e., $r = 1$. The total image attenuation coefficient α is therefore obtained, for each x-value, as the sum of the value read from the straight line for $a = \infty$ and half the value read from the straight line for $a = 1{\cdot}25$ (see Fig. 4). The two reflection-loss components $(L_R)_1$ and $(L_R)_2$ are obtained as straight lines in the chart shown in Fig. 8 (lines (1) and (2)). The total insertion loss (i.e., the sum of the two α curves and the two L_R curves) as a function of x is shown in Fig. 12 (b).

Example 2. Fig. 13 (a) shows a two-section low-pass filter* which has been designed to have the

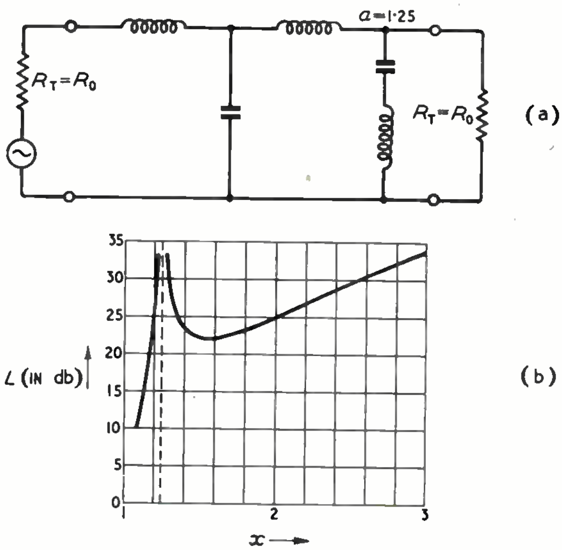

Fig. 12. *Circuit diagram and stop band insertion loss curve of $1\frac{1}{2}$-section low-pass filter (image parameter type).*

* This filter was originally designed analytically to produce a Tchebycheff approximation to zero loss in the pass band and to infinite loss in the stop band. For this purpose E was obtained by a transformation of elliptic functions as, for instance, described by Darlington (see ref. 10).

insertion loss (neglecting dissipation) given by

$$L = 10 \log_{10} (1 + E^2)$$

where $E = Hx \dfrac{(x^2 - x_1^2)(x^2 - x_2^2)}{(x^2 - a_1^2)(x^2 - a_2^2)}$

and $H = 70;\ x_1^2 = 1/a_1^2 = 0{\cdot}25163;$
$x_2^2 = 1/a_2^2 = 0{\cdot}57701.$

The chart in Fig. 10 shows the graphical evaluation of L where

$$\log|E/x| = \log H' + \log|\sinh(z - z_1)| + \log|\sinh(z - z_2)| - \log|\sinh(z + z_1)| - \log|\sinh(z + z_2)| \quad ..(12)$$

and $H' = Hx_1^2 x_2^2;\ z_1 = \log x_1;\ z_2 = \log x_2$.

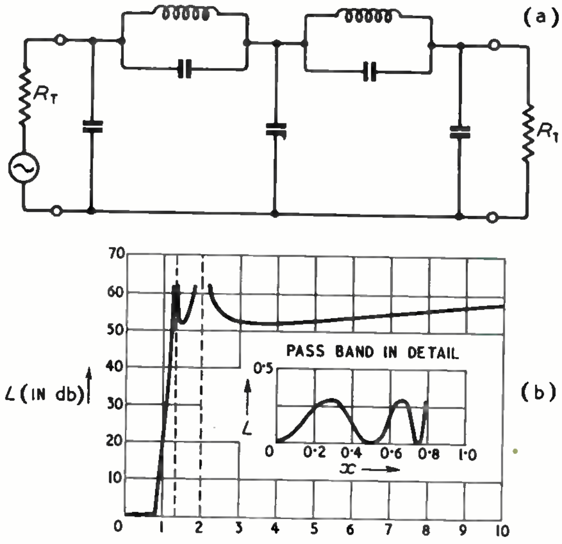

Fig. 13. *Circuit diagram and insertion loss curve of two-section low-pass filter (insertion parameter type).*

The corresponding L-curve is plotted in Fig. 13 (b). Log H' is represented by line (5) parallel to the x-axis. The other four terms in (12) are represented by the lines (1), (2), (3), (4) with slope + 1. The sum curve is curve (7). It is also plotted separately in Fig. 13 (b).

Acknowledgments

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APPENDIX

Definition of x and a for High-Pass, Band-Pass, and Band-Stop Filters.

For an m-derived low-pass filter section we have $x = f/f_o$ and $a = f_\infty/f_o$ where f is the frequency, f_o is the cut-off frequency and f_∞ the frequency of infinite attenuation. By defining x and a in a different way we can apply the charts discussed in this article to other types of filters. These definitions are given in the accompanying table. They make it possible to use the charts shown in Figs. 4 and 6 for all types of filters referred to below and the charts in Figs. 3, 8 and 10 for all types except dissymmetrical band-pass filters (the chart in Fig. 3 could be extended to cover the case of dissymmetrical band-pass filters.)

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TABLE

Type of filter	Cut-off frequencies	x	a
Low-pass	f_0	f/f_0	f_∞/f_0
High-pass	f_0	$-f_0/f$	f_0/f_∞
Symmetrical band-pass	f_1, f_2	$\dfrac{f - f_1 f_2/f}{f_2 - f_1}$	$\dfrac{f_{\infty 2} - f_{\infty 1}}{f_2 - f_1}$
Dissymmetrical band-pass (4-element type*)	f_1, f_2	$-\left(\dfrac{f_2^2 - f^2}{f_2^2 - f_1^2}\right)^{\frac{1}{2}}$	$\left(\dfrac{f_2^2 - f_{\infty 1}^2}{f_2^2 - f_1^2}\right)^{\frac{1}{2}}$
Dissymmetrical band-pass (4-element type†)	f_1, f_2	$+\left(\dfrac{f^2 - f_1^2}{f_2^2 - f_1^2}\right)^{\frac{1}{2}}$	$\left(\dfrac{f_{\infty 2}^2 - f_1^2}{f_2^2 - f_1^2}\right)^{\frac{1}{2}}$
Symmetrical band-stop	f_1, f_2	$-\dfrac{f_2 - f_1}{f - f_1 f_2/f}$	$\dfrac{f_2 - f_1}{f_{\infty 2} - f_{\infty 1}}$

* For $f > f_2$ (i.e., for the upper) } stop band, x becomes imaginary
† For $f < f_1$ (i.e., for the lower) }
This is the reason for the imaginary x-scale in the chart shown in Fig. 4.

'SAFETY' COLOUR CODE

After investigating the possibility of producing a safety colour code in which dangers, particularly in factories, are indicated by colour, the British Standards Institution has abandoned the attempt. An investigation was carried out on behalf of B.S.I. by the Royal Society for the Prevention of Accidents.

Two of the main difficulties which led to the decision are the general use of colours with traditional, if sometimes inconsistent, meanings and the fact that experience has shown existing colour codes to lose their significance quickly. In addition, the increasing scientific use of colours for decoration to secure better lighting and to improve working conditions militated against the choice for a satisfactory scheme.

INSTITUTION OF ELECTRICAL ENGINEERS

The Council of the Institution of Electrical Engineers has elected to Honorary Membership of the Institution:—

Sir Arthur Percy Morris Fleming, C.B.E., D.Eng., for his distinguished work in electrical engineering, in particular in the field of technical education, his contributions to scientific research, and his services to the Institution.

Sir Edward Appleton, K.C.B., G.B.E., M.A., D.Sc. LL.D., F.R.S., for his distinguished work in the field of pure and applied physics and his researches into the characteristics of the ionosphere and the part they play in determining the mode of propagation of radio waves.

The Council of the Institution has also made the thirtieth award of the Faraday Medal to:

Professor Ernest Orlando Lawrence, A.M., Ph.D., for his distinguished work in the field of nuclear physics.

I.E.E. MEETING

12th March. "The Slot Aerial and its Application to Aircraft", and "A Survey of External and Suppressed Aircraft Aerials for Use in the High-Frequency Band", by R. H. J. Cary, to be held at the Institution, Savoy Place, London, W.C.2 at 5.30 p.m.

BRIT.I.R.E. MEETING

27th March. "The Application of Magnetic Amplifiers to Industrial Measurement and Control", by H. M. Gale, B.Sc., to be held at the London School of Hygiene and Tropical Medicine, Keppel St., Gower St., London, W.C.1, at 6.30 p.m.

CORRESPONDENCE

Letters to the Editor on technical subjects are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

Fourier Anlaysis and Negative Frequencies

SIR,—In the January 1952 issue of *Wireless Engineer* Mr. I. J. Shaw states that the integrals:

$$s(\omega) = \int_{-\infty}^{+\infty} f(t) \exp(-j\omega t)dt \text{ and}$$

$$f(t) = \frac{1}{2\pi} \int_{-\infty}^{+\infty} s(\omega) \exp(j\omega t)d\omega$$

define the Fourier analysis of a function into a series of sine and cosine components.

This is not strictly correct. The integrals quoted define the analysis of a function into, and the assembly of a function from, a *continuous* frequency spectrum, while Fourier's analysis results in a special type of discontinuous line spectrum, and can therefore be presented in series form. The more general integral quoted by the writer is usually termed a Fourier transform of the function, and a departure from this distinctive nomenclature can only be made at the expense of clarity.

M. L. TELCS.

Regentone Research Laboratories,
Forest Gate, London, E.7.
11th January 1952.

Linear Diode Voltmeter

SIR,—Mr. G. D. Monteath has pointed out to me a serious error in my paper on the response of a linear diode voltmeter to randomly-recurrent impulses, which appeared in your issue of November 1951, p. 342.

In equation (10) the mean of the rectified voltage was incorrectly formed and should have been written as

$$\bar{v} = \frac{\overline{W}\ \overline{(1 - e^{-\beta s})}}{\beta \bar{s}}$$

$$= \frac{k}{\beta} \frac{Ac(1 - m)}{1 - m(1 - c)}$$

whence the rectification efficiency for randomly-recurrent impulses is

$$y = \frac{cx}{1 + cx}$$

which is always *less* than the efficiency y_0 for regularly-recurrent impulses. The solid-line curves for y in Fig. 3 require corresponding modification, and they are then found to lie very slightly below the dashed curves for y_0.

R. E. BURGESS.

Slough,
Bucks.
30th January, 1952.

NEW BOOKS

An Introduction to Applied Mathematics

By J. C. JAEGER. Pp. 445 + xiii. Oxford University Press, Amen House, London, E.C.4. Price 35s.

This book is based on lectures given by Prof. Jaeger in the University of Tasmania for students at the intermediate stage. He has certainly succeeded in providing "a course which is more interesting and useful to physicists and engineers than the more academic ones, but which at the same time gives as good a training for mathematicians." The book offers "a comprehensive course on ordinary differential equations and the subjects in which they occur, including the theory of vibrations, electric circuit theory, elasticity and selected physical problems, as well as particle and rigid dynamics. In addition, it contains an introduction to partial differential equations and their applications, together with topics such as special functions, Fourier series, Fourier and Laplace transforms, and numerical methods, which are required for their solution." Only a knowledge of the calculus and the fundamentals of statics and dynamics is assumed.

The style is very clear. Difficult proofs are often omitted, but the limitations of any methods discussed are always indicated, and appropriate up-to-date references for such proofs or for more detailed discussion are given. Each chapter has a large number of examples, to all of which answers are given. Naturally when such a wide range of topics is included, the treatment of many of them is introductory, but it does provide a sound and sufficient foundation; a student of somewhat more than average ability would be able to teach himself much if he rarely had any guidance other than this book. Prof. Jaeger clearly regards mathematics as a powerful tool to be used rather than a subject divided into watertight compartments and intended only for the initiated few. He has, therefore, included a remarkably large collection of methods and ideas useful in practice whose original applications may have belonged to many different branches of mathematics.

The printing of the book is clear. There are very few, if any, misprints; this is important in a book for students, who lack sufficient experience to be able to avoid wasting time and being misled by misprints.

The book makes a fresh approach to the problem of making clear the subject-matter of the mathematics required by the practical man. It also gives the mathematician a good idea of the practical utility of his subject as well as adequate technical training. It is unbiased by preconceived ideas and based on the firm foundation of long and successful teaching experience. It should be stimulating for teachers because of its practical and unusual approach as well as for reference; it contains so much otherwise scattered material in one volume. It should be invaluable to the students for whom it is primarily written, and should be freely available for them in libraries. It is a book which can be thoroughly recommended.

J. W. H.

Advanced Theory of Waveguides

By L. LEWIN. Pp. 192 with 54 illustrations. Published for *Wireless Engineer* by Iliffe & Sons, Ltd., Dorset House, Stamford St., London, S.E.1. Price 30s.

The early years of the development of waveguide theory involved mathematics which, although to most engineers then seemed heavy enough, were essentially straightforward and exact. Soon, however, experimental work outran the theory, and the theoreticians were faced with the difficult task of expressing mathematically the effect of discontinuities in the structure of a waveguide—the effect of diaphragms, junctions, open-ended guides, etc. While in most cases it was easy to formulate the problem as an integral equation, the solution of this equation in a usable form was a major difficulty. The methods of approximation developed are too involved for most books, although the results are now well known and freely used in design work.

A large part of the original work was done by Schwinger at M.I.T., and it is surprising that so little detail of it is given in the Radiation Laboratory Series. One would have expected a detailed treatment in the "Waveguide Handbook" but only an outline of the methods is given. Thus we have the curious situation that many people are familiar with results about whose derivation their only clue is in the now familiar reference "Unpublished report by J. Schwinger." The book under review repairs this deficiency. In it the author sets out to provide detailed solutions to a number of important problems in a form in which they can be most readily understood. It is a difficult task, for it is still 'advanced theory' and the reader must have a rather substantial background of function theory if he is to understand it fully.

After a mathematical introduction there are four chapters dealing with diaphragms and posts in waveguides, resonant windows, steps, junctions, and tapers. Then follow chapters on radiation from waveguides, and loaded and corrugated guides. Although the total number of pages is modest a great deal is packed in, since the author assumes that the reader has a knowledge of both fundamental waveguide theory and the expressions which he derives. Results once derived are not further discussed.

The reviewer feels that the quasi-static method devised by G. G. Macfarlane at T.R.E. should have received more attention. Although less powerful than the methods of Schwinger its close relation to the methods of solving electrostatic problems familiar to engineers would seem to make it a more suitable starting point for a subject which, however treated, is undoubtedly forbidding. Also a section outlining the nature of the different methods and their relation to each other would have been valuable. The reader is in some danger of having his view of the wood obscured by the trees.

Typographically the book is rather condensed, and an over-zealous use of the solidus has sometimes resulted in expressions whose meaning is not clear at first glance.

These are minor criticisms of a book which is a very useful and timely addition to the literature. All serious workers in this field should have it at hand for study and reference.

H. R. L. L.

Frequenz Modulation

By Paul Güttinger. Second edition. Pp. 194 with 101 illustrations. Verlag A.G. Gebr. Leemann & Co., Zürich. Price Fr. 29.

This book is very little changed from the first edition, which was published in 1947 and reviewed on p. 129 of the April 1948 *Wireless Engineer*. There appears to be no change whatever in the first 120 pages, but the chapter on Discriminators has been rewritten in view of the recent developments in this subject, and when valves are involved the data have been brought up to date. The bibliography has been increased from 295 to 405 references. The book deals very clearly and thoroughly with both theory and practice, and can be unreservedly recommended. It is a pity that the opportunity was not taken to correct the errors of spelling; as in the first edition, van der Pol is sometimes van der Pool, and Whittaker sometimes Whittacker; in both editions reference 58 turns an editorial note into an editional note.

G. W. O. H.

Steels in Modern Industry

Edited by W. E. Benbow. Pp. 562 + viii. Published for *Iron and Steel* by Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1. Price 42s.

This is a book by 29 specialist contributors which covers most aspects of modern steel. It is divided into four main sections—Introductory, General Properties influencing Engineering Design, Specific User Aspects and Surface Treatments. In the third section—on User Aspects, there are four chapters comprising 57 pages on electrical steels. They are:—High Permeability Alloys, by Professor N. F. Astbury; Permanent Magnets, by K. Hoselitz; Permalloys, by S. E. Buckley; and Non-Magnetic Steels and Cast Irons, by D. A. Oliver.

A large amount of useful information is compressed into these pages. The main magnetic properties are given, the structure of the material is discussed, including the effects of grain orientation, and magneto-striction effects are considered.

Microphones

By the Staff of the Engineering Training Department, British Broadcasting Corporation. Pp. 114 with 78 illustrations. Published for *Wireless World* by Iliffe & Sons, Ltd., Dorset House, Stamford St., London, S.E.1. Price 15s.

Applied Mechanics for Engineers

By Sir Charles Inglis. Pp. 404 + xii with 437 illustrations. Cambridge University Press, Bentley House, London, N.W.1. Price 42s.

Dielectric Breakdown of Solids

By S. Whitehead. Pp. 271 + xv. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 25s.

The chapter headings in this book give a good idea of its scope. They are:—Method of Treatment, Thermal Breakdown, Breakdown Caused by Discharges, Electrochemical Breakdown and Dielectric Breakdown in Practice.

The book covers the subject very thoroughly and, in spite of the formidable-looking six-page list of symbols, it is very largely non-mathematical. It is well illustrated.

Survey of Modern Electronics

By Paul G. Andres. Pp. 522 + x. Chapman & Hall, Ltd., 37 Essex St., London, W.C.2. Price 42s.

This book is of American origin and has 11 chapters:—Basic Concepts and Current Conduction, The Hot-Cathode Diode, The Vacuum Triode, Multigrid and Special Vacuum Tubes, Special-purpose Vacuum Tubes, Gas-filled Tubes, Photosensitive Tubes and Devices, Electronics in Instrumentation, Electronics in Communication, Electronic Controls, Electronics in Heating.

The treatment is elementary but not of a kind suited to a beginner. The reader must have a good general knowledge of electricity and physics. After reminding the reader of the appropriate physical basis of a device, the author describes it and then goes on to explain some of its applications. As an example, after dealing with triode characteristics the author gives some eight pages to amplifiers, and for his application he chooses the automatic pilot to which he devotes five pages.

The book is well illustrated and gives quite a good general picture of many applications of the valve in various branches of science and engineering.

W. T. C.

Cathode-Ray Oscillographs (4th Edition)

By J. H. Reyner, B.Sc., A.C.G.I., D.I.C., M.I.E.E., M.Inst.R.E. Pp. 199 + xi, with 138 illustrations. Sir Isaac Pitman & Sons, Ltd., Parker St., Kingsway, London, W.C.2. Price 15s.

STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

The service of standard frequencies transmitted from Rugby, MSF, by the Post office, on behalf of the National Physical Laboratory, has now been in operation for two years. The transmissions are intended to supplement those provided by the U.S. Bureau of Standards station WWV, and, in particular, to meet the needs of the United Kingdom and Western Europe. The present experimental programme provides a limited service on the three frequencies 60 kc/s, 5 Mc/s and 10 Mc/s of which the first is the most suitable for reception in this country. This transmission now constitutes the frequency standard of many government, commercial and university laboratories. The number of known users is steadily increasing and there are no doubt many other users and potential users who are not in touch with the Laboratory. It appears therefore that the regular publication in *Wireless Engineer* of the frequency of the transmissions, as determined at the National Physical Laboratory, will serve a useful purpose.

The value of a frequency, being measured in terms of the unit of time, is not known exactly until the final corrections to the time signals have been published. The values given must, therefore, be based on the predicted values of the laboratory standards and advance information of estimated time-signal errors made available to the Laboratory by the Royal Greenwich Observatory. This information takes into account the estimated annual fluctuation of the period of the earth's rotation, which recent work has shown to be present, so that the results given are based on the unit of uniform time from which the annual variation has been removed. The amplitude of this variation may not be constant however and in consequence it is still very difficult to predict with certainty the values of frequency with a precision exceeding 1 part in 10^8. In general, however, it is found that the predicted values differ by less than this amount from the final corrected values. In spite of these difficulties of prediction the frequencies of the transmissions have been successfully maintained within ± 2 parts in 10^8 of the nominal values. During the past two years the frequency of the quartz standard controlling the transmissions has increased slowly at the rate of a few parts in 10^9 per month and occasional adjustments of about -2 parts in 10^8 are made to keep the frequency within the stated tolerance.

The results for the 60-kc/s transmission are given in the second column of the table and are expressed as a deviation in parts in 10^8 from the nominal value. The same values will apply to the transmissions on 5 and 10 Mc/s but the received frequencies may in these cases differ from the transmitted frequencies by, in extreme cases, as much as 20 parts in 10^8 because of Doppler effects at the reflections in the transmission path. The 60-kc/s transmission is received by the ground wave, and the received and transmitted frequencies are not expected to differ by more than 2 parts in 10^9. The modulation frequencies of 1 000 c/s and 1 c/s are derived from the standard controlling the continuous wave and therefore have the same accuracy and differ from their nominal values by the same amount. The 1-c/s impulses consist of five cycles of the 1 000-c/s modulation and if a particular part of a cycle is used to denote an instant of time they can be used to define time intervals with a precision of 0·1 ms. These intervals are expressed on the same uniform time scale as used in the control of the frequency of the transmissions. The 1-c/s impulses are not regarded as time signals and their actual time of transmission relative to Greenwich Mean Time will gradually change if the frequency differs from its nominal value. In order that this difference should not exceed 100 ms a step adjustment of 50 ms or 100 ms is made when necessary on the first day of the month. The difference between the MSF 1-c/s impulses at 10 40 GMT and the GBR time signals at 10 00 GMT is given in the fourth column of the table of results.

In the third column the frequency of the Droitwich B.B.C. Station on 200 kc/s at 10 30 G.M.T. is given. The frequency variations of this station during the day are generally less than 1 part in 10^7 and it serves as a useful standard when the highest accuracy is not required.

It should be mentioned that the transmitter employed for the 60-kc/s signal also serves as a stand-by transmitter for another service, and that in consequence it is occasionally necessary to cancel the standard-frequency transmission on this frequency.

There is, of necessity, a time lag in publication, and the results given in this issue are those for January, but in cases of urgent immediate need the values can be obtained on request to the National Physical Laboratory, Teddington, Middx., where all enquiries concerning the service should be directed. Results will be published regularly in *Wireless Engineer*.

STANDARD-FREQUENCY TRANSMISSIONS

Values for January, 1952

Date 1952 January	Frequency deviation from nominal: parts in 10^8		Lead of MSF impulses on GBR 1000 G.M.T. time signal in milliseconds
	MSF 60 kc/s 1029-1130 G.M.T.	Droitwich 200 kc/s 1030 G.M.T.	
1	+ 0·3	− 2	− 31·4
2	+ 0·3	− 2	− 31·2
3	+ 0·3	− 3	− 30·9
4	+ 0·3	− 3	− 31·1
5	+ 0·2	− 3	− 30·7
6	N.T.	− 4	N.T.
7	N.T.	− 3	N.T.
8	+ 0·3	− 2	− 31·1
9	+ 0·5	− 1	− 30·8
10	+ 0·4	− 1	− 31·2
11	+ 0·5	0	− 30·0
12	+ 0·5	− 1	− 29·5
13	+ 0·6	− 1	− 30·2
14	+ 0·5	− 2	− 29·0
15	+ 0·6	− 1	− 28·4
16	+ 0·6	0	− 27·3
17	+ 0·8	0	− 28·2
18	+ 0·7	0	− 28·3
19	+ 0·7	− 1	− 27·3
20	+ 0·8	− 1	− 25·4
21*	+ 0·8	0	− 27·2
22	+ 0·7	+ 1	− 26·1
23	+ 0·8	+ 1	− 25·3
24*	+ 0·8	+ 1	− 25·1
25*	+ 0·8	+ 2	− 24·8
26	+ 0·8	+ 2	− 25·1
27*	+ 0·8	+ 2	− 24·5
28*	+ 0·8	+ 3	− 25·0
29*	+ 0·3	+ 2	− 26·0
30*	+ 0·5	+ 2	− 26·8
31*	+ 0·5	+ 3	− 28·4

N.T. = No transmission.

* = No MSF transmission at 1029 G.M.T. Results for 1429-1530 G.M.T.

ABSTRACTS and REFERENCES

Compiled by the Radio Research Organization of the Department of Scientific and Industrial Research and published by arrangement with that Department.

The abstracts are classified in accordance with the Universal Decimal Classification. They are arranged within broad subject sections in the order of the U.D.C. numbers, except that notices of book reviews are placed at the ends of the sections. U.D.C. numbers marked with a dagger (†) must be regarded as provisional. The abbreviations of the titles of journals are taken from the World List of Scientific Periodicals. Titles that do not appear in this List are abbreviated in a style conforming to it.

ACOUSTICS AND AUDIO FREQUENCIES

534.321.9 562

Making Ultrasonic Waves Visible.—R. Hanel. (*Radio Tech., Vienna*, Aug. 1951, Vol. 27, No. 8, pp. 325–329.) Description of simple schlieren equipment developed at the Technische Hochschule, Vienna.

534.321.91-14 563

Ultrasonic Measurements on Liquids.—C. E. Mulders. (*Tijdschr. ned. Radiogenoot.*, July 1951, Vol. 16, No. 4, pp. 155–169.) Review of methods of investigation.

534.41 : 534.78 564

The Sound-Film Spectrograph — an Instrument for the Acoustic Analysis of Speech and Other Rapidly Changing Sounds.—B. H. Edgardh. (*IVA, Stockholm*, 1951, Vol. 22, No. 5, pp. 134–153. In German.) The sound to be analysed is recorded on either film or magnetic tape in a number of parallel tracks, each corresponding to the frequency range of a particular band-pass filter. The equipment is compared with the Bell Telephone visible-speech spectrograph.

534.84 565

The Acoustics of Ancient Theatres.—F. Canac. (*Rev. sci., Paris*, May/June 1951, Vol. 89, No. 3311, pp. 151–166.) Investigation of the design and acoustic properties of historical open-air theatres, many photographs of which are reproduced, and discussion of the results of particular tests made using logatoms and by a stroboscopic ripple-tank method for the theatres at Orange and Vaison, France.

534.844.5 566

The Use of Artificial Reverberation in the Theatre.—A. Moles. (*Ann. Télécommun.*, Aug./Sept. 1951, Vol. 6, Nos. 8/9, pp. 245–249.) The introduction of artificial reverberation, produced by means of an auxiliary echo room, enables artistic requirements to be satisfied without impairing the intelligibility of speech. The relation between intelligibility and the slope of the sound-decay curve is given in a simple form and is verified experimentally.

534.846 567

Acoustics of the Royal Festival Hall, London.—P. H. Parkin. (*Nature, Lond.*, 18th Aug. 1951, Vol. 168, No. 4268, pp. 264–266.) A brief discussion of considerations taken into account in the design of the hall. The difficulty in interpreting the subjective criteria of the musician in terms of physical quantities is stressed. Data are given for reverberation time and noise level due to external sources, and comments of eminent musicians on the high quality of the hall are included.

534.861.1 568

Recording-Studio Design.—P. A. Shears. (*Wireless World*, Sept. 1951, Vol. 57, No. 9, pp. 355–360.) Various types of frequency distortion which may be caused by unsuitable studio design are discussed and the two typical defects of excessive reverberation time at low frequencies and 'flutter echo' at high frequencies are illustrated in a three-dimensional characteristic. An empirical relation between optimum reverberation time and hall volume is extrapolated to give guidance in the design of small studios. In large halls any natural resonances are usually at frequencies too low to give trouble, but in studios with volumes of the order of 3 000 ft^3 such resonances may occur in the range 50–150 c/s. Wall constructions and treatments for absorbing excess energy over various frequency ranges are described, with numerical detail.

534.861.1 569

Broadcasting Studios with Sound-Diffusing Walls.—C. Tutino & G. Sacerdote. (*Poste e Telecomunicazioni*, Jan. 1951, Vol. 19, No. 1, pp. 5–15.) An account of work recently carried out on studios in Milan and Turin. The walls and ceilings were lined with plaster moulded into semicylindrical shapes of uniform length but varying diameter, the moulds being arranged in groups, disposed alternately horizontally and vertically, so that the wall surface was as irregular as possible. Typical dimensions were: length, 90 cm; diameter, 16–32 cm. With this arrangement no resonance effects were detectable at frequencies within the combined range of violin and cello. Measurements were made on models and in the studios themselves to determine the effect of the arrangements on the acoustic properties of the rooms; experiments are still in progress.

534.874.1 + 621.396.621]: 519.241.1 570

Perturbation and Correlation Methods for Enhancing the Space Resolution of Directional Receivers.—Hunt. (See 790.)

621.395.61/.62 571
Reciprocity Relations for Electroacoustic Transducers and their Universal Electrical Equivalents.—F. A. Fischer. (*Arch. elekt. Übertragung*, Aug. 1951, Vol. 5, No. 8, pp. 382–384.)

621.395.623.8 572
Speech-Reinforcement System Evaluation.—L. L. Beranek, W. H. Radford, J. A. Kessler & J. B. Wiesner. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, pp. 1401–1408.) Assessment for six auditoria using subjective rating tests, word-articulation tests and a new 'terminal-word' test. A graphical method is presented for calculating the effect of the frequency response of the system, the reverberation time of the room, directivity of the loudspeaker and room noise. A flat response from 400 to 4 000 c/s is needed for good intelligibility; room reverberation has little effect if the loudspeaker system is sufficiently directive.

621.395.623.8 573
The Universal Radiator, a New Development in Radiator-Group Technique.—K. Feik. (*Elektrotechnik, Berlin*, Aug. 1951, Vol. 5, No. 8, pp. 365–372.) Formulae are given from which the directional characteristics of radiator groups, their power and amplification factor, can be determined. Results are presented for various types, including (*a*) circular groups, (*b*) linear groups, (*c*) twin circular groups, (*d*) combinations of circular and twin groups. Practical combinations for directional and all-round transmission are discussed.

621.396.611.21 : 621.317.382 574
Power Measurements on Ultrasonic Quartz Oscillators.—Schmitz & Waldick. (See 734.)

AERIALS AND TRANSMISSION LINES

621.315.212.011.2/.3 575
Effective Resistance and Effective Inductance of Current-Carrying Conductors at High Frequencies.—W. Taeger. (*Funk u. Ton*, Aug. 1951, Vol. 5, No. 8, pp. 422–429.) Consideration of a straight conductor, such as the inner conductor of a coaxial cable, shows that at h.f. the current distribution is not the same at all points of the cross-section, but that between the centre and the surface of the conductor there is a great difference of both current magnitude and phase. The resulting increase of effective resistance and decrease of inductance, as dependent on the frequency and on the diameter of the conductor, are calculated and shown graphically.

621.392 + 621.396.67] : 621.397.5 576
Practical TV Antenna and Transmission-Line Considerations.—(*Radiotronics*, Aug. 1951, Vol. 16, No. 8, pp. 155–179.) An account is given in simple terms of the fundamentals of radio emission and propagation and of the manner of operation of aerials and transmission lines. Various types of aerial and array useful for television reception are described and illustrated; performance is discussed, with numerical examples.

621.392.017.13 : 621.3.011.22 577
Radiation Resistance of a Two-Wire Line.—J. E. Storer & R. King. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, pp. 1408–1412.) A general formula for the radiation resistance is derived by integration of the normal component of the Poynting vector over a large sphere surrounding the line. The result is in agreement with that computed by other methods. Formulae are presented for the special cases of a lossless system and a nonresonant line.

621.392.018.78† 578
Pulse Distortion in RC and LG Lines.—K. Steinbuch. (*Arch. elekt. Übertragung*, Aug. 1951, Vol. 5, No. 8, pp. 354–360.) The symbols R, C, L and G denote respectively the series resistance, shunt capacitance, series inductance and shunt conductance of a line. Thin-wire cables used in the a.f. range are typical RC lines. Lines characterized mainly by L and G are of little practical importance, but are nevertheless of interest since coils and transformers with iron cores have an LG line as circuit equivalent. Use of the error integral in conjunction with operational calculus enables formulae to be derived permitting numerical calculation of signal transmission along both types of line. Undistorted transmission and reflection effects are discussed. The theory is applied to the transmission of a broadcasting programme on the phantom circuit of a line without coil loading, which can be regarded as an RC line.

621.392.09 579
Cylindrical Surface-Wave Transmission Lines.—H. M. Schmidt. (*Z. angew. Phys.*, July 1951, Vol. 3, No. 7, pp. 272–279.) A comprehensive analysis of the theory, principles and characteristics of dielectric-covered transmission lines. The results of other workers in the field are summarized and 31 references are given.

621.392.26† : 621.317.329 580
Determination of Aperture Parameters by Electrolytic-Tank Measurements.—Cohn. (See 725.)

621.392.26† : 621.39.09 581
Propagation of U.H.F. Electromagnetic Waves in Waveguides of Circular Cross-Section: Part 2.—H. Frühauf. (*Elektrotechnik, Berlin*, July 1951, Vol. 5, No. 7, pp. 315–321.) Formulae analogous to those for rectangular waveguides (35 of January) are here derived for circular waveguides.

621.392.26† : 621.396.611.39 582
Directional-Coupler Errors.—F. A. Benson. (*Wireless Engr*, Dec. 1951, Vol. 28, No. 339, pp. 371–372.) In the type of coupler using two windows $\lambda/4$ apart, errors in measurements of voltage s.w.r. or power may result from reflections at the windows. The errors depend on the relative phase of the transmitted and reflected waves and on the phases of the reflections at the windows.

621.396.67 583
Distribution of Radiation Resistance along a Rod Aerial: Aerial as Coil Line with Transformer Coupling.—O. Zinke. (*Funk u. Ton*, Aug. 1951, Vol. 5, No. 8, pp. 393–399.) An equivalent circuit is considered, in which the aerial is represented by an iterative network of coils and capacitors whose values differ along the line. This circuit enables the distribution of the radiation resistance along the aerial to be determined. The analysis also gives a simple explanation of the frequency dependence of the resistance. This agrees, for aerials with current maximum at the foot (electrically short aerials or those excited in odd harmonics), with the frequency dependence determined by integration of the radiation intensity in the distant field.

621.396.67 584
Plane Aerials of Small Width.—S. Zisler. (*Ann. Télécommun.*, Aug./Sept. 1951, Vol. 6, Nos. 8/9, pp. 214–222.) Theory is developed by considering the plane aerial as a system of parallel linear conductors whose number tends to infinity. Kirchhoff's equations are applied, and simple expressions are derived for the current distribution and input impedance; results are in good agreement with values found by experiment. Radiation characteristics are also calculated.

621.396.67 : 621.317.336 585

The Measurement of Antenna Impedance using a Receiving Antenna.—E. O. Hartig, R. King, T. Morita & D. G. Wilson. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, pp. 1458–1460.) Energy from a remote transmitter excites a receiving aerial erected vertically over a large conducting plane and base-loaded by a vertical slotted coaxial cavity of variable length. Resonance-curve measurements enable the aerial impedance to be determined. Curves of the measured impedance as a function of the electrical length of the aerial are given. Excellent agreement is obtained with the impedance values for the same aerial when base-driven through the slotted section. Both sets of measurements are in good agreement with the King-Middleton second-order theory.

621.396.67.011.21 586

The Impedance of an Antenna over a Large Circular Screen.—J. E. Storer. (*J. appl. Phys.*, Aug. 1951, Vol. 22, No. 8, pp. 1058–1066.) ". . . treats the problem of an antenna erected vertically in the center of a circular screen. An integral equation is obtained for the electric field in the plane of the screen, outside the screen. This equation is solved approximately by the use of a variational principle, and a formula is obtained for the change of antenna impedance as a function of the diameter of the screen."

621.396.67.011.21 587

Influence of a Plane Reflector on the Input Impedance of a Thick Cylinder.—S. Zisler. (*Ann. Télécommun.*, July 1951, Vol. 6, No. 7, pp. 205–212.) Data are presented in tables and graphs for facilitating the calculation of the input impedance of a cylindrical aerial with a plane reflector, using the double-line theory previously developed (2645 of 1951).

621.396.67.011.21 588

Mutual Impedance of Wire Aerials.—L. Lewin. (*Wireless Engr*, Dec. 1951, Vol. 28, No. 339, pp. 352–355.) For the general case of two straight wire aerials carrying sinusoidal currents, it is possible to evaluate the mutual impedance in terms of the Si and Ci functions. A demonstration of the method for the case of two coplanar $\lambda/2$ dipoles is given. The special cases of dipoles parallel or forming an X or V are studied. See also 589 below (Medhurst), 1932 Abstracts, p. 585 (Carter) and 1933 Abstracts, p. 214 (Murray).

621.396.67.011.21 589

Dipole Aerials in Close Proximity.—R. G. Medhurst. (*Wireless Engr*, Dec. 1951, Vol. 28, No. 339, pp. 356–358.) A treatment of the problem of finding the mutual impedance of crossed half-wave dipoles, leading to a solution in terms of Si and Ci functions. Owing to the assumption of zero thickness of the wires, the limiting cases of the V and X arrangements when the included angle becomes zero, and of the parallel arrangement when the distance becomes zero, give different values for the mutual reactance. See also 588 above (Lewin), 1932 Abstracts, p. 585 (Carter), and 1933 Abstracts, p. 214 (Murray).

621.396.67.018.424† 590

The Folded Fan as a Broad-Band Antenna.—R. L. Linton, Jr. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, pp. 1436–1444.) The results of model studies in the frequency range 100–1 350 Mc/s are used to design a naval aerial operating within the communication band of 2–27 Mc/s, having a 4 : 1 frequency range and a maximum power loss of 18·5%, due to mismatch, when connected to a 52-Ω line.

621.396.671 + 621.396.11 591

Application of the Compensation Theorem to Certain Radiation and Propagation Problems.—G. D. Monteath. (*Proc. Instn elect. Engrs*, Part IV, Oct. 1951, Vol. 98, No. 1, pp. 23–30.) Summary abstracted in 2648 of 1951.

621.396.671 592

Current and Charge Distributions on Antennas and Open-Wire Lines.—D. J. Angelakos. (*J. appl. Phys.*, July 1951, Vol. 22, No. 7, pp. 910–915.) Results of measurements on cylindrical aerials and their feeders are shown graphically. The presence of a stub support modifies the distributions on the aerial only near the junction of the aerial, feeder and stub, but for aerial loads near antiresonance the distributions on the feeder as well as the impedances of the system are altered considerably. A corrective network for the region of the junction is discussed.

621.396.676 593

The Design of an Omni-directional Aerial System for the Frequency Range 225–400 Mc/s.—F. A. Kitchen. (*Proc. Instn elect. Engrs*, Part III, Nov. 1951, Vol. 98, No. 56, pp. 409–415. Discussion, pp. 465–470.) Description of the development of a double-conical monopole aerial with counterpoise skirt, suitable for installation on the yard-arm of a naval vessel. The aerial dimensions were finally adjusted after a series of measurements of impedance at frequencies within the operating range. Experimental data indicated that the semi-perimeter of the aerial in any vertical plane should be approximately one wavelength at 300 Mc/s, the mid-band second-order-resonance frequency. Results are given of measurements of the variation of terminal impedance, voltage s.w.r. and radiation pattern with frequency. A coaxial 72-Ω feeder is connected directly to the two radiating elements, no matching transformer being necessary.

621.396.676.001.57 : 621.317.336 594

The Use of Complementary Slots in Aircraft-Antenna Impedance Measurements.—J. T. Bolljahn & J. V. N. Granger. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, pp. 1445–1448.) Description of a method for eliminating the effect of the feeder cable in measurements of wing-cap and tail-cap aerial impedances with the aid of models. The method gives greater measurement accuracy than that obtainable with conventional techniques, but its use is restricted to simple types of aerial. Typical measurement results are given.

621.396.677 595

A Vertical Nonrotating Directional Antenna System.—J. K. Chapman. (*QST*, July 1951, Vol. 35, No. 7, pp. 20–23.) A receiving aerial system for amateur use on 6, 10 and 20 m. Three vertical dipoles are arranged equidistantly. Any two are fed in antiphase to give coverage over a 120° sector. The main beam in the vertical plane covers all useful elevations on all three working frequency bands. A considerable saving in mast height relative to a horizontal aerial is claimed.

621.396.677 596

Radiation Field of Helical Antennas with Sinusoidal Current.—E. T. Kornhauser. (*J. appl. Phys.*, July 1951, Vol. 22, No. 7, pp. 887–891.) A rigorous formula for the radiation field of a helical aerial is derived, assuming a current distribution determined experimentally by Kraus (3033 of 1947). For a helix of several turns this formula yields results very nearly the same as those obtained by Kraus's approximate method (1860 of 1949), but computation is simpler and the formula is applicable to helices with a nonintegral number of turns.

621.396.677 : 621.317.335.3† 597

Artificial Dielectrics for Microwaves.—Sharpless. (See 727.)

621.396.677.6.029.6† : 621.396.931/.933].2 598

Rotating H-Type Adcock Direction-Finders for Metre and Decimetre Wavelengths.—H. G. Hopkins & F. Horner. (*Proc. Instn elect. Engrs*, Part IV, Oct. 1951, Vol. 98, No. 1, pp. 112–126.) "Instruments of high precision for the range 26–600 Mc/s (0·5–12 m wavelength) are described, and details of their performance are given. The direction-finders at the lower end of this frequency range are of high sensitivity and have seen considerable practical service. Development has proceeded largely on empirical lines, but from this work a fair appreciation has now been obtained of the fundamental factors affecting performance and of the practical means for taking them into account. Some progress has been made, for example, in understanding the cause of polarization errors, which are of importance in some—but not all—d.f. applications at these frequencies."

538.566 + 621.396.67 599

Electromagnetic Waves and Radiating Systems. [Book Review]—E. C. Jordan. Publishers: Prentice-Hall, New York, 710 pp., 32s. 6d. (*Brit. J. appl. Phys.*, July 1951, Vol. 2, No. 7, pp. 205–206.) A comprehensive treatise, of an introductory character, but not over-simplified; vector analysis is used as the basis of the treatment.

621.392.26† 600

Advanced Theory of Waveguides. [Book Review]—L. Lewin. Publishers: Iliffe & Sons, London, 192 pp., 30s. (*Wireless Engr*, Dec. 1951, Vol. 28, No. 339, p. 374.) "Covers posts, diaphragms, windows, steps, tapers and T-junctions in waveguides. Radiation from waveguides is treated as well as propagation in loaded and corrugated guides."

CIRCUITS AND CIRCUIT ELEMENTS

621.3.012.8 601

Electrical-Equivalent Circuits.—K. Küpfmüller. (*Fernmeldetech. Z.*, Aug. 1951, Vol. 4, No. 8, pp. 337–346.) Detailed review of their application in the representation of electrodynamic, physical and physico-chemical phenomena.

621.3.013.5 : 621.3.011.23 : 621.314.2.045 602

The Calculation of the Magnetic Field of Rectangular Conductors in a Closed Slot, and its Application to the Reactance of Transformer Windings.—E. Billig. (*Proc. Instn elect. Engrs*, Part IV, Oct. 1951, Vol. 98, No. 1, pp. 55–64.) "The magnetic vector potential of current-carrying conductors in a rectangular slot is the same as that due to an infinite number of images of these conductors from all the four walls of the slot. A solution of this problem can thus be obtained in the form of a Fourier series, periodic in both the x and y directions, the constants of the solution being determined by the boundary conditions, i.e., by the dimensions of the slot and of the conductors, and by the currents passing through them. Expressions for the magnetic vector potential due to any conductor arrangement can thus be developed, and these lend themselves to considerable simplification without undue loss of accuracy."

621.3.015.7† : 621.387.4† 603

A Sweep-Type Differential and Integral Discriminator.—E. Fairstein. (*Rev. sci. Instrum.*, Oct. 1951, Vol. 22, No. 10, pp. 761–765.) A circuit is described for determining the pulse-height distributions from scintillation counters, proportional counters, parallel-plate counters and other pulse sources. It will operate with any positive-output amplifier of rise time $\geqslant 0{\cdot}1\ \mu s$ and output limited to 100 V.

621.3.015.7† : 621.387.4† 604

A High-Precision Pulse-Height Analyser of Moderately High Speed.—G. W. Hutchinson & G. G. Scarrott. (*Phil. Mag.*, July 1951, Vol. 42, No. 330, pp. 792–806.) Designed for nuclear research work. Information is stored in an ultrasonic delay line and displayed on a c.r. screen. The accuracy of channel width and the linearity of response are both within 1 part in 1 000. The storage capacity may be varied to give 60 channels of up to 10^6 pulses each, 80 channels of up to 3×10^4 pulses each or 120 channels of up to 1 023 pulses each, with a maximum counting rate of 1 600 sec.

621.314.2 + 621.318.4 605

Winding Space Determination.—N. H. Crowhurst. (*Electronic Engng*, Aug. 1951, Vol. 23, No. 282, pp. 302–306.) The factors controlling the choice of wire gauge, insulation and winding methods for transformers and chokes are briefly summarized. The use of abacs for simplifying the calculations involved is described with examples.

621.314.2 606

Calculation of Small Transformers.—E. Donauer. (*Funk u. Ton*, July 1951, Vol. 5, No. 7, pp. 369–374.) Design formulae and curves are given which are applicable to multi-winding transformers suitable for power packs and using either M or E-I stampings. A numerical example is worked out.

621.314.58 607

The Magnetic Modulator.—R. Feinberg. (*Radio tech. Dig., Édn franç.*, 1951, Vol. 5, Nos. 4 & 5, pp. 217–226 & 281–287.) French version of 338 of February.

621.316.726.078.3 : 621.3.015.3 608

Transient Response of a Narrow-Band Automatic Frequency-Control System.—T. Miller. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, pp. 1433–1436.) Description of a method of analysing the response of a.f.c. systems operating in conjunction with narrow-band-pass filters. A time lag, equivalent to the reciprocal of the bandwidth, is assigned to the filter. Circuit parameters are determined for the case of operation at nearly critical damping. The equations of the system are derived by means of the Laplace transform, and the transient response of the system to a step change of input frequency is evaluated by the method of residues.

621.318.423 : 621.3.011.22 609

The Resistance of Round-Wire Single-Layer Inductance Coils.—A. H. M. Arnold. (*Proc. Instn elect. Engrs*, Part IV, Oct. 1951, Vol. 98, No. 1, pp. 94–100.) "Butterworth's two formulae for the resistance of short coils with a finite number of turns are merged into a single formula valid for coils of any length and having any number of turns. Numerical values of the functions appearing in the formula are given in tables. The formula is shown to give results in reasonable agreement with the experimental figures of Medhurst (1694 of 1947) and Hickman (Bureau of Standards Scientific Paper No. 472)."

621.318.572 610

A Comprehensive Counting System for Nuclear Physics Research.—N. F. Moody, W. D. Howell, W. J. Battell & R. H. Taplin. (*Rev. sci. Instrum.*, July 1951, Vol. 22, No. 7, pp. 439–461.) A method of constructing counting systems from a number of standardized sub-units is described. Details of the design of these sub-units are given, the aim being to attain versatility of function and reliability in performance. The synthesis of various instruments from these sub-units is described. Further sections of the survey to be published later will deal with amplitude analysers.

621.319.53 : 621.316.729 **611**

The Controlled Tripping of High-Voltage Impulse Generators.—A. S. Husbands & J. B. Higham. (*J. sci. Instrum.*, Aug. 1951, Vol. 28, No. 8, pp. 242–245.) A triggered spark-gap and associated circuits are described which enable a generator to be discharged in synchronism with measuring equipment such as a c.r.o. or rotating-mirror camera. A tripping pulse of only about 5 kV is required; the tripping of a single-stage generator can be performed within 0·1 μs of a predetermined short delay time.

621.319.53 : 621.396.619 **612**

High-Power Pulse Generator with Controlled Spark-Gap.—E. Prokott. (*Fernmeldetech. Z.*, Aug. 1951, Vol. 4, No. 8, pp. 347–351.) Description of a compressed-air spark generator with repetition frequency 8–18 kc/s, and investigation of its suitability as a modulator for telecommunication purposes.

621.392 : 517.433 **613**

Operational Approach to Nonlinear Circuit Analysis.—G. H. Cohen. (*J. Franklin Inst.*, July 1951, Vol. 252, No. 1, p. 63.) Correction to paper noted in 3077 of 1949.

621.392 : 517.544.2 **614**

The One-Sided Green's Function.—Miller. (See 711.)

621.392 : 621.317.3.083.4 **615**

Double-T Networks for Null Measurements at High Frequency.—Samal. (See 724.)

621.392.43 **616**

High-Frequency Matching Transformer.—F. Steiner. (*Öst. Z. Telegr. Teleph. Funk Fernsehtech.*, July/Aug. 1951, Vol. 5, Nos. 7/8, pp. 93–100.) In a tuned wide-band matching transformer, reactance developed in the damped parallel-tuned secondary circuit at frequencies away from resonance gives rise to large variations of apparent input impedance. Design formulae are derived for a transformer in which the series-tuned primary circuit partially compensates for these variations.

621.392.5 **617**

Application of Matrices to Four-Terminal-Network Problems.—H. P. Biggar. (*Electronic Engng*, Aug. 1951, Vol. 23, No. 282, pp. 307–311.) The relation of matrices to network equations is explained and simple matrix algebra is applied to the derivation of a constant-resistance equalizer with balanced input and unbalanced output.

621.392.5 : 621.3.015.3 **618**

Transient Response. Conditions for Monotonic Characteristics.—I. F. Macdiarmid. (*Wireless Engr*, Nov. 1951, Vol. 28, No. 338, pp. 330–334.) The necessary and sufficient conditions for a monotonic transient response are considered for the case of a network to which a unit current-step is applied. The location of the zeros of the impedance function on the complex-frequency plane is shown to be as important as the location of the poles. Conditions for monotonic transient response are derived for networks having two poles and two zeros in the complex-frequency plane; the results are applied in discussion of a compensated anode load fed by a triode valve.

621.392.5 : 621.3.015.7† : 621.3.018.7 **619**

Pulse Distortion.—S. H. Moss. (*Proc. Instn elect. Engrs*, Part IV, Oct. 1951, Vol. 98, No. 1, pp. 37–42.) "For waveforms of simple shapes certain features may be defined: content, epoch, spread, skewness, squatness, etc., which are affected in a very simple way by passage through a linear system (which is regular at low frequencies). In fact, by proper definition, they are affected only additively by constants which are independent of the applied waveform, and characteristic only of the system. These invariants for the pulses and for the system correspond to the cumulants used to describe statistical distributions."

621.392.5 : 681.142 **620**

A Design of an Ultrasonic Delay-Line.—T. Gold. (*Phil. Mag.*, July 1951, Vol. 42, No. 330, pp. 787–791.) Design and construction details of a vertical folded Hg delay line, for use in an electronic memory unit, giving a delay of 1·2 ms with a bandwidth of several megacycles per second.

621.392.5.001.8 **621**

Linear Electromechanical Quadripoles.—U. John. (*Frequenz*, June & July 1951, Vol. 5, Nos. 6 & 7, pp. 166–173 & 190–192.) Analysis of the applicability of electrical circuit theory to electromechanical phenomena. General equations for the forward and backward dynamic impedances and overall damping of a passive transducing circuit are derived and developed for application to specific circuits. A detailed mathematical treatment is given for an electrostriction process.

621.392.52 **622**

Design of Electric Wave Filters with the Aid of the Electrolytic Tank.—A. R. Boothroyd. (*Proc. Instn elect. Engrs*, Part IV, Oct. 1951, Vol. 98, No. 1, pp. 65–93. Summary, *ibid.*, Part III, Nov. 1951, Vol. 98, No. 56, pp. 486–492.) The analogue representation (in terms of complex frequency) of the properties of image-parameter transfer functions of the Zobel type by current flow in an electrolyte tank provides a convenient method for determining filter insertion-loss characteristics. The tanks used are developments of the double-layer tank described by Boothroyd, Cherry & Makar (2743 of 1949). A transformation is developed by means of which the approximation problem can be solved for a specified low-pass-filter insertion loss, the poles and zeros of the insertion modulus function of the filter being accurately determined by simple measurements in the electrolyte tank.

621.392.52 **623**

The Multisection RC Filter Network Problem.—L. Storch. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, pp. 1456–1458.) Two methods for deriving the filter characteristics from the basic circuit equations are described. The methods, unlike that of Tschudi (1622 of 1950), take nothing for granted but Ohm's and Kirchhoff's laws. The first, a finite-difference method, leads to the solution almost immediately. The second method makes use of image parameters suitable for cascade connection of symmetrical structures.

621.392.52 : 538.221 **624**

Ferrites as Magnetostrictive Resonators and their Application as Electrical Filter Elements.—C. W. Diethelm. (*Tech. Mitt. schweiz. Telegr.-Teleph Verw.*, 1st Aug. 1951, Vol. 29, No. 8, pp. 281–297. In German, with French summary.) Methods of production and magnetic properties of MgZn, CoZn, and NiZn mixed ferrites are discussed. Measurements show that NiZn ferrite with Zn ferrite content 0 to 40% exhibits a strong magnetostriction effect and relatively high permeability with practically no eddy-current losses. *Q*-factor lies between 1 000 and 3 000. Two bridge-type filter circuits with a 4-kc/s pass band at 40 and 80 kc/s respectively are described. The power transmitted in the pass band is about 1 mW.

621.392.52 : 621.396.611.4 **625**

Microwave Filters employing a Single Cavity Excited in More than One Mode.—Wei-Guan Lin. (*J. appl. Phys.*, Aug. 1951, Vol. 22, No. 8, pp. 989–1001.) A cavity resonator with input and output couplings constitutes a network with two pairs of terminals and with an infinite number of possible modes of oscillation. In some cavities of special shape, several degenerate modes with identical natural frequencies can occur. In a single cavity, these degenerate modes can be coupled together to form a chain of coupled circuits by perturbation of the otherwise ideal geometrical configuration of the cavity. The filter characteristics of such devices are analysed and applied to the design of multi-mode filters. Experimental models of 2-, 3-, and 5-mode filters are described, with insertion-loss curves.

621.392.52 : 621.397.61 **626**

The Vestigial-Sideband Filter for the Sutton Coldfield Television Station.—E. C. Cork. (*Proc. Instn elect. Engrs*, Part III, Nov. 1951, Vol. 98, No. 56, pp. 460–464. Discussion, pp. 465–470.) The specification of the filter is outlined and the reason for the choice of a complementary constant-resistance network filter of the Norton type is explained. The basic design formulae relevant to the chosen network are given, with information on the inversion and replacement of lumped elements by coaxial lines. The results of measurements on the performance of the adopted practical circuit show agreement with that of the idealized network.

621.392.52.072.6 **627**

Alignment and Adjustment of Synchronously Tuned Multiple-Resonant-Circuit Filters.—M. Dishal. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, pp. 1448–1455.) The method described for rapidly tuning a filter is to couple very loosely a detector to the first resonator and then to tune consecutively all odd-numbered resonators for maximum detector output and all even-numbered resonators for minimum detector output, ensuring that all resonators following the one being tuned are completely detuned. The theory of the method is given and the technique of adjustment of circuit constants in the filter is considered.

621.396.6 + 621.385 **628**

New Radio Components in the World Market.—M. Alixant. (*Radio tech. Dig., Édn franç.*, 1951, Vol. 5, Nos. 1–3, pp. 3–61, 67–89 & 170–177.) Classified review giving details of new components and apparatus now available in Europe and America; tables of valve characteristics are included.

621.396.6 : 655.3 **629**

Practical Assembly of Printed Circuits.—R. Singer. (*Électronique, Paris*, May & June 1951, Nos. 54 & 55, pp. 18–20 & 13–17.)

621.396.611.1 **630**

Some Sawtooth Oscillations.—T. Vogel. (*Ann. Télécommun.*, July 1951, Vol. 6, No. 7, pp. 182–190.) An analytical study is made of circuit systems in which abrupt alternations between two states occur. Approximate solutions are found by applying Poincaré's method of trajectories, the sawtooth being represented by a mathematical discontinuity of a certain order. Starting with the multivibrator as a particular example, generalized equations are developed; the periodic solutions found satisfactorily represent the operation of the circuit.

621.396.611.34/.35 : 621.3.015.7† **631**

RC-Coupling Network for Pulse Transmission. Criteria for Maximum Pulse Sharpness.—H. Moss. (*Wireless Engr*, Nov. 1951, Vol. 28, No. 338, pp. 345–349.) Analysis for a RC differentiator circuit acting in conjunction with a normal intervalve-coupling network leads to expressions defining the conditions for maximum pulse sharpness. Experimental results confirm the theory.

621.396.611.4 **632**

On the Influence of Circular Holes in Electromagnetic Cavity Resonators.—W. Klein. (*Z. angew. Phys.*, July 1951, Vol. 3, No. 7, pp. 253–259.) Experimental investigation at wavelengths of 10 and 25 cm of the alteration of resonance wavelength and damping due to apertures in a cavity wall. The limits of application of theory are determined by examination of the experimental results. Two or more cavity resonators with an aperture in the common wall constitute a system of coupled circuits for which a theory is developed for determination of the coupling factor. As in coupled circuits for medium frequencies, there is a critical value of coupling above which the waveform in the secondary cavity is of the double-hump type.

621.396.615.17/.18 **633**

Arrangement for Division and Multiplication of Frequencies and Frequency Bands.—H. Wüstner. (*Funk u. Ton*, July 1951, Vol. 5, No. 7, pp. 374–376.) Short description of a method (patent applied for) by which the multiplication or division can be effected without the occurrence of harmonics or combination frequencies. A tuned circuit is used in conjunction with either a rectifier or valve input circuit.

621.396.615.17 **634**

Synchronizer for 100-kc/s Square-Wave Generator.—L. C. Hedrick. (*Rev. sci. Instrum.*, July 1951, Vol. 22, No. 7, p. 537.) The generators previously described (851 of 1950) have been found defective owing to lack of stability in the synchronizer. A new synchronizer is here described which has proved entirely satisfactory, one unit having been run continuously for a week without loss of synchronism.

621.396.615.17 **635**

A Generator for Pulses of Variable Length.—A. Gilardini. (*Poste e Telecomunicazioni*, Aug. 1951, Vol. 19, No. 8, pp. 401–406.) Analysis of May's circuit (853 of 1950) and suggested modification by connection of one of the diodes of a 6AL5 valve across the terminals of the grid resistor of one valve, the other diode being applied to the input of the following amplifier stage as ordinary d.c. restorer. This results in perfect linearity of the pulse length characteristic, and constant pulse amplitude as the pulse length is varied.

621.396.615.17.029.64 **636**

Harmonic Generation in the U.H.F. Region by means of Germanium Crystal Diodes.—F. D. Lewis. (*Gen. Radio Exp.*, July 1951, Vol. 26, No. 2, pp. 6–8.) Diodes were used to derive up to the second and fifth harmonics of 900- and 400-Mc/s oscillators respectively. The available power falls from about 60 mW at 500 Mc/s to 2 mW at 2 000 Mc/s for Type-1N34A diodes. Circuit data are given. The maximum power output from Si crystals is only about 30% of that from Ge crystals in the range 400–1 000 Mc/s.

621.396.645 **637**

Design of Input Circuit of a Capacitor-Microphone Amplifier.—U. Kirschner. (*Arch. elekt. Übertragung*, Aug. 1951, Vol. 5, No. 8, pp. 385–391.) The reaction of the acoustical-mechanical system of a capacitor microphone on the electrical system results in a complex internal impedance. Amplifier design is discussed with special reference to this and to polarization voltage, distortion and the input resistance of the valve used. See also 18 of January.

621.396.645 : 621.317.3 **638**

Degree of Amplification of Amplifiers for Electrical Measurements.—F. Moeller. (*Arch. tech. Messen*, Aug. 1951, No. 187, pp. T94–T95.) Review of the characteristics of the various types of amplifier, with 29 references.

621.396.645 : 621.385.3/.4 : 546.289 **639**

Transistor Amplifiers: Part 1—Operation and Characteristics.—H. Fricke. (*Arch. tech. Messen*, July 1951, No. 186, pp. T80–T81.) Review with 24 references.

621.396.645 : 621.385.3/.4 : 546.289 **640**

Transistor Amplifiers: Part 2—Circuits and Construction Types.—H. Fricke. (*Arch. tech. Messen*, July 1951, No. 186, pp. T82–T83.) Review with 18 references.

621.396.645.012.8 **641**

Network Representation of Input and Output Admittances of Amplifiers.—F. W. Smith. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, p. 1331.) Correction to 2392 of 1951.

621.396.645.371 **642**

Negative Feedback Amplifiers with Desired Amplitude-Frequency Characteristics.—V. J. Cooper. (*J. Televis. Soc.*, April/June 1951, Vol. 6, No. 6, pp. 233–245.) Four types of feedback which provide flat characteristics are defined. An analysis of single- and two-stage amplifiers indicates how the required characteristics may be achieved. Response curves obtained experimentally with amplifiers of up to three stages support the theoretical conclusions and demonstrate the advantages of two of the types of feedback considered.

621.396.822 : 519.2 **643**

Expected Number of Crossings of Axis by Linearly Increasing Function plus Noise.—Lehan. (See 715.)

GENERAL PHYSICS

530.145 : 51 **644**

Mathematical Aspects of the Quantum Theory of Fields: Parts 1 & 2.—K. O. Friedrichs. (*Commun. pure appl. Math.*, Aug. 1951, Vol. 4, Nos. 2/3, pp. 161–224.) The introduction sets out the ground to be covered, with remarks about functional and spectral representation. Part 1 is concerned with field operators under the headings: simultaneous spectral representation of infinitely many operators; commutation rules and improper operators; the differential equations; the energy interval; motivation of the configuration space representation. Part 2 deals with particle representation as follows: biquantization; occupation number representation; annihilation and creation operators; time variation of these operators and representation of field operators; trace operators; oscillators; Hermite functionals and integration over the Hilbert space. Parts 3–6 to follow.

534.372 **645**

On the Damping of Vibrating Cylindrical Rods by the Surrounding Medium.—H. O. Kneser. (*Z. angew. Phys.*, March/April 1951, Vol. 3, Nos. 3/4, pp. 113–117.)

535.13 **646**

An Asymptotic Solution of Maxwell's Equations.—M. Kline. (*Commun. pure appl. Math.*, Aug. 1951, Vol. 4, Nos. 2/3, pp. 225–262.) The electromagnetic field due to an arbitrary charge distribution with harmonic time behaviour is related to the pulse field produced by the same distribution suddenly placed in space at time $t = 0$. Asymptotic expansions for the field in the harmonic case can be obtained if certain discontinuities in the pulse solution are known. A method is given whereby the required discontinuities can be determined without finding the complete pulse solution. The asymptotic expansions give the geometrical-optics approximation to the time harmonic field in the limit when the wavelength approaches zero. The theory can be applied to the problem of the field created by a dipole in an inhomogeneous medium and it may be possible to extend it to deal with more elaborate situations.

The form of the asymptotic expansion given and its derivation from Duhamel's principle are due to the late R. K. Luneberg, who also commenced work on the derivation of the ordinary differential equations for the coefficients of the expansion from discontinuity conditions. The portions of this paper which repeat Luneberg's work are included for completeness, as the material was not published before his death.

535.37 : 621.32 **647**

Luminous Capacitors: a New Light Source Based on Electro-Luminescence.—(*Elect. Times*, 19th July 1951, Vol. 120, No. 3115, pp. 100–105.) See 1341 of 1951 (Payne, Mager & Jerome).

536.49 : 621.319.4 **648**

On the Thermo-Dielectric Effect.—J. C. Ribeiro. (*An. Acad. brasil. Cienc.*, 30th Sept. 1950, Vol. 22, No. 3, pp. 325–348. In English.) Description and discussion of an effect observed in a capacitor whose dielectric is partly in the solid and partly in the liquid state, one of the plates being in contact with the solid and the other with the liquid phase; when solidification or melting occurs at the interface, an electric current is produced. The effect may be responsible for certain phenomena of atmospheric electricity.

537.311.31 **649**

Metallic Conduction—The 'Internal Size-Effect'.—D. K. C. Macdonald. (*Phil. Mag.*, July 1951, Vol. 42, No. 330, pp. 756–761.) The effect of internal structural discontinuities in limiting the electron mean free path in metals is considered as an explanation of the anomalous resistance and magnetoresistance of gold and other metals at low temperatures and of the anomalous magnetoresistance of ferromagnetic metals.

537.523.4 **650**

Observations on the Electrical Breakdown of Gases at 2 800 Mc/s.—W. A. Prowse & W. Jasinski. (*Proc. Instn elect. Engrs*, Part IV, Oct. 1951, Vol. 98, No. 1, pp. 101–111.) "Electrical discharges at 2 800 Mc/s are produced in a nosed-in cavity type of resonator by energizing it from a pulsed magnetron. Individual pulses of various durations in the range 0·25 μs to 2·5 μs are employed. Electrons are provided in mid gap by the short ultraviolet radiation from an auxiliary d.c. spark actuated from the circuit used to trigger the power pulse."

537.525.6 **651**

Dielectric Constant and Electron Density in a Gas Discharge.—R. E. B. Makinson, P. C. Thonemann, R. B. King & J. V. Ramsay. (*Proc. phys. Soc.*, 1st Aug. 1951, Vol. 64, No. 380B, pp. 665–670.) Measurements at frequencies of the order of 1 kMc/s were made of the impedance of a coaxial transmission line terminating in a small electrode immersed in the plasma of a low-pressure discharge in Hg vapour. The possible use of such impedance measurements to determine electron density is discussed.

537.525.6 652

Plasma Oscillations.—D. Gabor. (*Brit. J. appl. Phys.*, Aug. 1951, Vol. 2, No. 8, pp. 209–218.) A comprehensive review of plasma oscillations and of electronic oscillations determined by the internal dynamics of a discharge rather than by the outer circuit. A new mathematical formulation is given for oscillations in irrotational streams. Research is needed particularly on the following: electronic processes in magnetrons; theory of vortex motion; and the establishment of a satisfactory model for radiating stellar atmospheres.

537.525.6 : 537.562 653

Measurement of the Electron Density in Ionized Gases by Microwave Techniques.—M. A. Biondi. (*Rev. sci. Instrum.*, July 1951, Vol. 22, No. 7, pp. 500–502.) Measurements are made during the period following a discharge through the gas, the electron-density changes being determined from the detuning of a cavity resonator. Densities from 10^6 to 10^{10} electrons/cm^3 can be measured.

537.525.6 : 538.56 654

On Oscillations in Electron Streams.—R. Q. Twiss. (*Proc. phys. Soc.*, 1st Aug. 1951, Vol. 64, No. 380B, pp. 654–665.) The substitution method of determining the possibility of oscillation in electron streams, in which the dispersion equation is examined for complex roots of ω in terms of the propagation vector **k**, is critically discussed. This method of analysis does not have physical meaning unless the boundary and initial conditions are taken into account. In the infinite plasma treated by Bohm & Gross (88 and 89 of 1950) it is not possible to distinguish formally between amplification and instability; this ambiguity may be resolved by postulating boundary and initial conditions, e.g., those at the two planes $z = 0$ and $z = d$. A two-velocity electron stream is discussed in detail, the analysis using the Laplace transform being given in an appendix. It is concluded that in the unidimensional case the longitudinal plasma oscillation can only become unstable if feedback arises from a reverse electron beam, or from a wave reflected from a surface of discontinuity or boundary of the plasma.

537.525.6 : 538.56] : 523.5 655

Plasma Oscillations in Meteor Trails.—J. A. Clegg & R. L. Closs. (*Proc. phys. Soc.*, 1st Aug. 1951, Vol. 64, No. 380B, pp. 718–719.) An account of radar observations on λ 4 m of the columns of ionization produced during the Geminid shower of December 1948. Aerials with orthogonal polarizations were adjustable so that the electric vector was along or transverse to the trail. The echoes were classified as of short ($<$ 0·15 sec) or long ($>$ 0·15 sec) duration. The ratio transverse/longitudinal polarization amplitude exceeded unity but decreased during the lifetime of the larger echoes. The observations are regarded as evidence of plasma resonance in the majority of trails observed.

537.533.8 656

Fundamentals of Secondary-Electron Emission.—M. A. Pomerantz & J. F. Marshall. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, pp. 1367–1373.) Review of basic phenomena and of various theories, none of which appear entirely satisfactory.

537.566 : 538.566 657

The Ionization and Luminescence of Flames.—P. Goercke, E. Saenger & I. Bredt. (*Ann. Télécommun.*, Aug./Sept. 1951, Vol. 6, Nos. 8/9, pp. 250–260.) Measurements of the reflection of electromagnetic waves from the exhaust gases of rockets show that the degree of ionization is much higher than hitherto assumed. Theory in accordance with these findings is developed by taking account of the fact that the gas is not in an equilibrium state.

537.568 658

Concerning the Mechanism of Electron-Ion Recombination.—M. A. Biondi & T. Holstein. (*Phys. Rev.*, 15th June 1951, Vol. 82, No. 6, pp. 962–963.) Discussion of investigations by various workers.

537.71 659

An Introduction to the Rationalized M.K.S. System of Units.—G. F. Nicholson. (*Brit. J. appl. Phys.*, July 1951, Vol. 2, No. 7, pp. 177–182.)

538.311 : 621.318.423 : 513.647.1 660

Wave Propagation on Helical Wires.—W. Sollfrey. (*J. appl. Phys.*, July 1951, Vol. 22, No. 7, pp. 905–910.) The field equations and boundary conditions are formulated exactly and a solution is obtained in terms of powers of the ratio of wire thickness to distance between turns. A new coordinate system is introduced in which a helical wire of circular cross-section appears as a surface with one coordinate constant. Maxwell's equations and the e.m. boundary conditions are expressed in terms of this system and a perturbation method is applied to obtain approximate solutions of the equations. The results indicate a principal mode which is propagated along the wire with the velocity of light. The theory also predicts transverse electric fields on the axis, of the same order of magnitude as the longitudinal fields. These transverse fields determine the minimum magnetic field required to maintain a stable electron beam along the axis.

538.566 661

Propagation in a Non-homogeneous Atmosphere.—B. Friedman. (*Commun. pure appl. Math.*, Aug. 1951, Vol. 4, Nos. 2/3, pp. 317–350.) A new exposition of the theory of propagation over a spherical earth where the dielectric constant of the atmosphere varies radially from the earth's centre. The methods and results are similar to those of Watson, van der Pol, Bremmer and Rydbeck, with some novelties as follows:—(*a*) the dielectric constant is taken as a single function of position instead of having different functions in different regions; (*b*) the contour integral for the Hertz potential is carefully examined; this integral vanishes over the infinite semicircle, even for an arbitrary atmosphere; the potential may then be expressed as a sum of residues plus an integral which vanishes identically for a perfectly conducting earth, and is small compared with the first term of the residue series when the complex dielectric constant of the earth is much larger than that of the atmosphere; (*c*) it is emphasized that the propagation problem reduces to the eigenvalue problem for an ordinary differential equation, so that the W.K.B. method should be applied; (*d*) the degree of accuracy of the flat-earth theory as an approximation of the exact spherical-earth theory is considered; (*e*) a new approach is made to the case of tropospheric propagation in the presence of a duct, and the solution is expressed in terms of Hankel functions of order one-quarter.

538.566 662

Electric Waves along a Dielectric Cylinder surrounded by a Dielectric, One or Both of the Media being Plasma.—W. O. Schumann. (*Z. Naturf.*, April 1950, Vol. 5a, No. 4, pp. 181–191.) The following cases are analysed: (*a*) dielectric cylinder in plasma atmosphere, (*b*) plasma cylinder in dielectric atmosphere, (*c*) plasma cylinder in plasma atmosphere. The stationary waves formed between two plane conducting sheets perpendicular to the cylinder axis are also investigated. In consequence of the dispersion of the dielectric constant of a plasma and since it can have a negative value, many types of wave are possible. In most cases propagation is possible only within a limited frequency range. The phase velocity may increase or decrease considerably with the frequency.

Surface waves, with low phase and group velocities and strong energy concentration close to the surface of the cylinder, are possible in all cases.

538.566 : 535.13 **663**

Field Representations in Spherically Stratified Regions.—N. Marcuvitz. (*Commun. pure appl. Math.*, Aug. 1951, Vol. 4, Nos. 2/3, pp. 263–315.) A general method is given whereby a representation may be obtained of the e.m. field produced by prescribed sources in a spherically stratified medium. The field is expressed by a superposition of mode functions chosen to permit a simple evaluation of the associated amplitude functions. In this way Maxwell's equations are transformed so that the solution is reduced to that of scalar equations for guided waves along the r or θ directions. The problem thus becomes that of the solution, as a function of the mode index, of an ordinary second-order inhomogenous equation. A procedure for the solution of the eigenvalue problem set by this equation is described; the use of the δ function is involved. Complete sets of mode functions for use in typical problems are derived. The application of the results obtained to practical problems in terrestrial radio wave propagation is pointed out.

538.566 : 535.312 **664**

Reflection of Electromagnetic Waves from Slightly Rough Surfaces.—S. O. Rice. (*Commun. pure appl. Math.*, Aug. 1951, Vol. 4, Nos. 2/3, pp. 351–378.) Theoretical treatment of reflection from a perfectly conducting surface which has small random deviations from a plane. From expressions for the field components, average values are found in order to obtain the reflection coefficient, which is found to depend on polarization in a similar way to that of an almost perfectly conducting plane. A modified form of the reflection analysis is used to study propagation along the surface. Reflection from an imperfectly conducting rough surface is also considered briefly.

621.3.064.43 **656**

Arcing at Electrical Contacts on Closure: Part 1—Dependence upon Surface Conditions and Circuit Parameters.—L. H. Germer. (*J. appl. Phys.*, July 1951, Vol. 22, No. 7, pp. 955–964.)

538.114 + 538.221 **666**

Ferromagnetism. [Book Review]—R. M. Bozorth. Publishers: D. Van Nostrand Co., New York, 1951, 968 pp., $17.50. (*J. Franklin Inst.*, July 1951, Vol. 252, No. 1, p. 93.) "It is a book . . . that will be useful to the physicist interested in the fundamentals of ferromagnetism, to the metallurgist working with magnetic materials, and to the design engineer adapting new methods and materials to apparatus needs . . . extremely valuable as a survey of the field and as a source for further references."

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.7 **667**

The Possible Nature and Electromagnetic Origin of the Observed Pulsations of the Diameter of the Sun.—L. Gialanella. (*R. C. Accad. naz. Lincei*, July/Aug. 1951, Vol. 11, Nos. 1/2, pp. 60–62.)

523.72 + 523.8] : 621.396.822 **668**

Radio Astronomy.—J. S. Hey. (*Sci. Progr.*, July 1951, Vol. 39, No. 155, pp. 427–448.) An outline of the general principles of extraterrestrial radio noise reception, illustrated by examples from recent work.

550 **669**

Transactions of Oslo Meeting [of the International Union of Geodesy and Geophysics], **August 19-28, 1948.**—J. W. Joyce, Ed. (*Int. Ass. terr. Magn. Elect. Bull.*, 1950, No. 13, 568 pp.) These Transactions include national reports on research done up to 1947 on terrestrial magnetism, atmospheric electricity, the ionosphere and related subjects, together with the text or title of numerous papers presented at the meeting.

550.384 **670**

Typical Daily Variations of the Geomagnetic Field Components at Potsdam, and their Interpretation.—J. Bartels. (*Z. Met.*, July/Aug. 1951, Vol. 5, Nos. 7/8, pp. 236–239.) The mean daily curves were calculated for the solstice periods, for quiet days with zero and with high relative sunspot number, and for uniformly disturbed days. An unexpectedly strong variation with sunspot number is found for the quiet-day curves in winter. This indicates that the physical nature of the solar W radiation varies with solar activity; the height of the ionosphere layers ionized by the W radiation varies inversely as the sunspot number.

550.384.3 **671**

The Analysis of the Geomagnetic Secular Variation.—F. J. Lowes & S. K. Runcorn. (*Philos. Trans. A*, 16th Aug. 1951, Vol. 243, No. 871, pp. 525–546.) The analysis shows that the major part of the secular variation field for epoch 1922–1925 is explained by about twelve vertical dipoles below the surface of the earth's core. "The depth of the dipoles confirms that the origin of the secular variation must lie in the core of the earth; because of the high electrical conductivity of the core material it must in fact be due to a thin current sheet at the surface of the core, and this interpretation also gives an explanation for the existence of only vertical sources. The presence of only vertical sources, and in particular the presence of several near the equator, does not support the existence of the toroidal field, which is an essential step in Bullard's dynamo theory of the main field."

551.510.535 **672**

Note on Triple Splitting in the Ionosphere.—W. Becker. (*Z. angew. Phys.*, March/April 1951, Vol. 3, Nos. 3/4, pp. 83–88.) Marked variation of the polarization coefficient with height can occur if the collision frequency approaches a critical value, even when the ionization gradient is small. This value defines the region of transition from quasitransverse to quasilongitudinal propagation. Conditions for reflection and absorption of the ordinary and extraordinary waves are determined from a short mathematical analysis. The sharpness of the trace of the third component observed in echo-sounding at variable frequency is explained by the fact that such echoes can only be received in the direction of the earth's magnetic field.

551.510.535 **673**

Notes on the Height Fluctuation of the Ionosphere F_2 Layer.—R. Eyfrig. (*Z. angew. Phys.*, March/April 1951, Vol. 3, Nos. 3/4, pp. 96–103.) Analysis of data from numerous stations relative to the dependence of the (M 3 000) F_2-layer factor on the relative sunspot number. The running 12-monthly means for 1944–1947 show a nearly linear relation for almost all stations. After the solar-cycle peak the m.u.f. factor rises sharply for one group of stations and decreases further for a second group. The stations of both groups appear to be distributed geographically at random. Huancayo is an exception; monthly means show the highest linear correlation, $-0{\cdot}966$ for midday and $-0{\cdot}961$ for midnight values (see also 890 of 1950). For midday values the magnetic equator represents a line of symmetry; for midnight values the effect of geographical latitude is predominant.

551.510.535 . 621.3.087.4 674

Echo Sounding of the Ionosphere at Oblique Incidence.—W. Dieminger. (*Z. angew. Phys.*, March/April 1951, Vol. 3, Nos. 3/4, pp. 90–96.) Review of methods of synchronizing transmitter and receiver for fixed- and variable-frequency working. Traces recorded using quartz-clock synchronization for pulse reception and receiver tuning are shown, and results are briefly discussed.

551.510.535 : 621.396.11 675

Spectral Representation of Space-Wave Reception and the Ionosphere.—Spork. (See 780.)

551.510.535(98) 676

Thickness of Winter F Layer in Polar Regions.—M. W. Jones. (*Trans. Amer. geophys. Union*, April 1950, Vol. 31, No. 2, Part 1, pp. 187–190.) The half-thickness t of the F layer, as calculated by the Booker-Seaton method, for the winter months at College, Alaska, decreased from a monthly mean of 24 km for 1941–1942 to 13 km for 1943–1944. This decrease coincides with the decrease in total sunspot number. For the period October–December 1948 the mean value of t was 60 km and the 5-fold increase is believed to correspond with increase in sunspot number. Contour graphs show the mean diurnal variations of t for each month of the above-mentioned periods.

551.594 677

New Electric Effect in Icing by Sleet Formation in Naturally Supercooled Mists.—H. Lueder. (*Z. angew. Phys.*, July 1951, Vol. 3, No. 7, pp. 247–253.) Measurements were made of the charge acquired by ice forming on an earthed metal rod rotating in a supercooled mist on a mountain peak. This charge is negative. Results indicate that particles of vapour settle only partly as ice, the remainder rebounding in liquid form with a positive charge.

551.594.6 678

A Note on the Similarity of Certain Atmospherics Waveforms.—W. F. Zetrouer & W. J. Kessler. (*J. Franklin Inst.*, Aug. 1951, Vol. 252, No. 2, pp. 137–141.) Photographic records of atmospherics associated with particular thunderstorms observed in Florida are discussed. Of 104 night-time waveforms identifiable with a surface cold front extending over the midwestern states, 55% had similar fine structure. Of 520 daytime waveforms associated with a surface cold front moving over the edge of the Gulf Stream 41% were of similar type.

551.594.6 : 621.3.018.7.087.4/.5 679

Automatic Atmospherics-Waveform Recorder.—C. Clarke & D. E. Mortimer. (*Wireless Engr*, Dec. 1951, Vol. 28, No. 339, pp. 359–370.) A description of equipment for recording the changes in electric field constituting the atmospherics due to lightning discharges. The amplifier is aperiodic and covers the range 100 c/s–100 kc/s. At maximum gain, an input signal of 8 mV is required to give full-scale deflection on a 6-in. c.r. tube. The waveform appears on two c.r. tubes simultaneously, linear single-stroke timebases of short and long duration respectively serving to display on one tube the initial h.f. portion of the wave, and on the other the l.f. 'tail' associated with distant atmospherics. The timebases are triggered by the atmospheric. After each exposure on the two 35-mm-film cameras, the film is automatically moved on to the next frame, 40 exposures per minute being possible. Provision is made for synchronization with the Meteorological Office network of c.r. direction finders so that the origin of each recorded atmospheric may be determined.

LOCATION AND AIDS TO NAVIGATION

621.396.9 : 551.578.1/.4 680

A Quantitative Study of the 'Bright Band' in Radar Precipitation Echoes.—P. A. Austin & A. C. Bemis. (*J. Met.*, April 1950, Vol. 7, No. 2, pp. 145–151.) Observations and measurements of the bright band are presented and discussed. The theory attributing the phenomenon to the coalescence and melting of snowflakes affords an adequate explanation.

621.396.9 : 551.578.1 681

Vertical Recording of Rain by Radar.—S. K. H. Forsgren & O. F. Perers. (*Acta polyt., Stockholm*, 1951, No. 87, 19 pp.) Report of observations with radar equipment operated on a wavelength of 3·2 cm with output power of 7·5 kW, pulse duration 0·5 μs and repetition rate 300/sec. Anomalous echo patterns are illustrated and discussed. A record showing a triple echo is in good agreement with theoretical curves for multiple reflections from a scattering layer.

621.396.933 682

The American Plan for Air Traffic Control. A Description of SC31.—D. O. Fraser. (*J. Inst. Nav.*, July 1951, Vol. 4, No. 3, pp. 213–231. Discussion, pp. 232–236.) Summary of a report by the Radio Technical Commission for Aeronautics which outlines a comprehensive scheme for the development of control facilities during the next 15 years. The functions of the various ground and airborne units of equipment are described briefly and an example of the use of the facilities is given.

621.396.933 683

Modern Aircraft Safety Equipment.—K. Witmer. (*Bull. schweiz. elektrotech. Ver.*, 10th March 1951, Vol. 42, No. 5, pp. 125–135. In German.) A review of the principles and operation of radio communication equipment, radio beacons, d.f. systems, radar navigation aids, air traffic control systems, and aids to landing in bad weather conditions.

MATERIALS AND SUBSIDIARY TECHNIQUES

533.5 684

Molecular Flow in Connected Tubes.—W. Harries. (*Z. angew. Phys.*, Aug. 1951, Vol. 3, No. 8, pp. 296–300.) Probability theory is used in an analysis of molecular flow problems encountered in vacuum technique.

535.37 : 539.234 685

Transparent Luminescent Films.—F. J. Studer, D. A. Cusano & A. H. Young. (*J. opt. Soc. Amer.*, Aug. 1951, Vol. 41, No. 8, p. 559.) Two methods of producing such films are described. In the first, a clear film of the phosphor is deposited on a heated glass surface by the reaction of appropriate vaporized materials. The second method consists in evaporating a film of ZnF_2 on to a glass surface and then converting it to ZnS by heating in a stream of H_2S. The best films, made by the first method, are Mn-activated ZnS films. They have approximately half the brightness of conventional television phosphors and have orange-yellow luminescence.

535.37 : 621.385.832 686

Phosphors for Cathode-Ray Tubes.—L. Levy & D. W. West. (*J. Televis. Soc.*, Jan./March 1951, Vol. 6, No. 5, pp. 178–183.) The properties of various phosphors are discussed critically in relation to the characteristics of c.r. tube screens for direct-viewing and projection television, also for certain radar applications.

537.226.2 **687**

A General Law including as Particular Cases the Various Empirical Formulae proposed by Various Authors to represent the Variation of Dielectric Constant of a Solvent as a Function of Temperature.—T. Erben. (*Bull. tech. Univ. Istanbul*, 1950, Vol. 3, No. 1, pp. 45–60. In French.)

537.312.6 : 621.315.592† **688**

Manufacture, Regulating Action and Applications of Thermistors.—E. Meyer-Hartwig & H. Federspiel. (*Bull. schweiz. elektrotech. Ver.*, 10th March 1951, Vol. 42, No. 5, pp. 135–142. In French.) The physical properties of the materials used in thermistors are described, manufacturing processes are outlined for low-power and high-power units, and examples of their use are illustrated.

538.221 **689**

Magnetic Materials and Ferromagnetism.—A. E. de Barr. (*Research, Lond.*, Aug. 1951, Vol. 4, No. 8, pp. 366–371.) A survey paper discussing the properties of modern magnetic materials in the light of domain theory of ferromagnetism.

538.221 **690**

On the Dielectric and Magnetic Properties of some Ferrites at High Frequency.—F. Wagenknecht. (*Frequenz*, June & July 1951, Vol. 5, Nos. 6 & 7, pp. 145–155 & 186–190.) Report of investigations of ferrites of Mg, Mn, Fe, Ni, Cu, Pb and CuPb in the frequency range 170–3 285 Mc/s. The system FeO-Fe_2O_3 was specially dealt with. Preparation of the samples is described; their properties and factors influencing them are tabulated and discussed in relation to molecular structure.

538.221 **691**

Resistance Anomalies in a High-Permeability Nickel-Iron-Molybdenum Alloy.—F. Assmus & F. Pfeifer. (*Z. Metallk.*, Oct. 1951, Vol. 42, No. 10, pp. 294–299.) Variations of permeability and resistance of supermalloy subjected to additional tempering are investigated. As well as the expected increase of permeability, increase of cold resistance is observed, together with dependence of hot resistance on rate of cooling. These effects differ from those observed in permalloy but are similar to those observed in other alloys, e.g., Ni-Cr.

538.221 : 669.15 **692**

Iron-Silicon Alloys Heat Treated in a Magnetic Field.—M. Goertz. (*J. appl. Phys.*, July 1951, Vol. 22, No. 7, pp. 964–965.) Heat treatment of Fe-Si alloys in a magnetic field results in much improved magnetic properties, the highest maximum permeability being obtained in an alloy with about 6·5% Si. For a single crystal of this composition, magnetic annealing nearly closed the hysteresis loop and increased the maximum permeability from 5×10^4 to $3{\cdot}8 \times 10^6$, the highest value yet reported.

539.234 : 546.57 : 537.312 **693**

Temperature Variation of the Electrical Properties of Films containing Cavities.—J. P. Borel. (*C. R. Acad. Sci., Paris*, 23rd July 1951, Vol. 233, No. 4, pp. 296–297.) The electrical resistance of Ag films of thickness less than 10 mμ does not obey Ohm's Law; such films are lacunary in character. The voltage/current ratio increases irreversibly with temperature in the range 15°C–150°C. For films of thickness 11–12 mμ the corresponding variation is reversible.

539.234 : 546.57 : 537.312 **694**

Variation of the Resistivity of Thin Metal Films as a Function of Thickness and Temperature.—J. P. Borel. (*Helv. phys. Acta*, 20th Sept. 1951, Vol. 24, No. 4, pp. 389–400. In French.) See 693 above.

546.212 : 621.3.011.5 **695**

The Dielectric Behaviour of Water in Water-Dioxan Mixtures.—H. F. Cook. (*Trans. Faraday Soc.*, July 1951, Vol. 47, No. 343, pp. 751–755.) Report of investigation at microwave frequencies. The experimentally derived static dielectric constants of mixtures are analysed in terms of Kirkwood's theory for liquid dielectrics. The relaxation time of water in water-dioxan mixtures is greater than the value in pure water by a factor of approximately 2 at the greatest concentrations investigated.

546.23 : 537.311.33 **696**

Conductivity and Hall Effect of Micro-crystalline Selenium containing Iodine Impurities.—K. W. Plessner. (*Proc. phys. Soc.*, 1st Aug. 1951, Vol. 64, No. 380B, pp. 681–690.) The increase in conductivity arising from increased iodine content is due not to an increase in current carriers, but to an increase in their apparent mobility owing to modification of the intergranular barriers. The conductivity of specimens of the same dimensions prepared under different crystallizing conditions is shown to increase with increasing size of microcrystals. Carrier concentration decreases with temperature, in agreement with X-ray diffraction evidence of greater crystal perfection at higher temperatures.

546.23 : 548.55 : 537.311.33 **697**

Conductivity, Hall Effect and Thermoelectric Power of Selenium Single Crystals.—K. W. Plessner. (*Proc. phys. Soc.*, 1st Aug. 1951, Vol. 64, No. 380B, pp. 671–681.) Single crystals were grown from the vapour phase. Conductivity obeys the law $\sigma = \sigma_0 \exp(-\mathbf{e}E/\mathbf{k}T)$ with $\mathbf{e}E = 0{\cdot}13$ eV. Ohm's Law is not obeyed for applied fields > 5 V/cm. Both thermoelectric power and Hall effect rise slightly with increasing temperature, indicating a decreasing concentration of current carriers (positive holes). The evidence points to the existence of intergranular barriers in single crystals.

546.23 : 548.55 : 537.311.33 **698**

Electrical Properties of Selenium: Part 1 — Single Crystals.—H. W. Henkels. (*J. appl. Phys.*, July 1951, Vol. 22, No. 7, pp. 916–925.) The dark resistivity of crystals grown in a melt was studied as a function of axis orientation, temperature, field, and time of application of field. The large values found for thermoelectric power indicate hole conduction with a hole density of the order of 10^{14}/cm³, the density decreasing with temperature increase above room temperature. Mobilities and activation energies were also determined.

546.47-31 : 537.311.33 **699**

Some Electrical Properties of Zinc Oxide Semiconductor.—E. E. Hahn. (*J. appl. Phys.*, July 1951, Vol. 22, No. 7, pp. 855–863.) Results and discussion of conductivity and Hall-coefficient measurements.

546.48-31 + 546.74-31 **700**

Some Conduction Properties of the Oxides of Cadmium and Nickel.—C. A. Hogarth. (*Proc. phys. Soc.*, 1st Aug. 1951, Vol. 64, No. 380B, pp. 691–700.) Results of measurements of electrical conductivity and thermoelectric power of CdO and NiO at temperatures up to 500°C and at various pressures of the surrounding oxygen are shown graphically; they are in general agreement with theory.

546.74 : 548.55 **701**

Some New Bitter Patterns on a Single Crystal of Nickel.—L. F. Bates & G. W. Wilson. (*Proc. phys. Soc.*, 1st Aug. 1951, Vol. 64, No. 380A, pp. 691–695.) An investigation of domain magnetization processes using the experimental technique originated by Bitter.

546.817.221 702

The Conductivity/Temperature Characteristics of Lead Sulphide: The Influence of Oxygen and of the Rate of Heating.—W. Ehrenberg & J. Hirsch. (*Proc. phys. Soc.*, 1st Aug. 1951, Vol. 64, No. 380B, pp. 700–706.) Equipment is described for recording conductivity/temperature curves at heating rates up to 5 000°C/sec, and the results of extensive measurements on PbS in an oxygen atmosphere are discussed.

546.817.221 : 535.61-15 : 535.345.1 703

Infrared Transmission of Galena.—W. Paul, D. A. Jones & R. V. Jones. (*Proc. phys. Soc.*, 1st June 1951, Vol. 64, No. 378B, pp. 528–529.) Single crystals of galena were found to be sensibly opaque up to about 3 μ, beyond which the transmission rose sharply to a maximum at about 4·5 μ, then falling more slowly to a low value at 10 μ. The rise of transmission beyond 3 μ coincides with the sharp fall in the photoconductivity of thin films of PbS at room temperature and also in the photovoltaic effect shown by crystals with point contacts.

548.0 : 537.228.1 704

Piezoelectric Behaviour of Partially Plated Square Plates Vibrating in Contour Modes.—R. Bechmann & P. L. Parsons. (*Proc. phys. Soc.*, 1st Aug. 1951, Vol. 64, No. 380B, pp. 706–712.) A continuation of work described previously [2208 of 1951 (Bechmann)]. Measurements on square crystals are used to check the theoretical solution for the motion. For the longitudinal mode-2 described by Ekstein (523 of 1945) a particularly sensitive test of the theory is possible. Experiment confirms that with a critical size of electrodes the piezoelectric excitation vanishes.

548.0 : 549.514.51 : 539.37 705

Piezocrescence—the Growth of Dauphiné Twinning in Quartz under Stress.—L. A. Thomas & W. A. Wooster. (*Proc. roy. Soc. A*, 7th Aug. 1951, Vol. 208, No. 1092, pp. 43–62.) The behaviour of plates and bars of quartz, held at about 400° C while they were twisted or bent by external means, or while strained by means of a lengthwise temperature gradient, is explained in terms of a reversible phenomenon, the growth of one crystallographic orientation out of another under the influence of stress, for which the term 'piezocrescence' is proposed. Piezocrescence may also be expected in other crystals such as titanates, felspars and boracite.

621.314.63 706

Effect of Temperature on the Height of Potential Barriers and on the Breakdown Voltage of Contact Rectifiers.—E. Billig. (*Proc. phys. Soc.*, 1st Aug. 1951, Vol. 64, No. 380A, pp. 752–753.) Measurements of the contact resistance of standard Se, Ge and Si rectifiers indicate a barrier of constant height for temperatures above room temperature. The decrease observed at lower temperatures suggests that the barrier disappears at absolute zero. In some rectifiers (e.g., Se) the breakdown voltage is lowered by a decrease in temperature, while in others (e.g., Ge contact rectifiers) the turnover voltage increases at low temperatures, at least down to the temperature of liquid air.

621.315.61 707

On High Frequency Power Loss of Dielectrics.—K. Higasi & Y. Ozawa. (*J. phys. Soc. Japan.*, July/Aug. 1951, Vol. 6, No. 4, pp. 280–281.) Power loss in a dielectric is not determined directly by the loss tangent but is related to the h.f. conductivity σ. Thus a maximum value of tan δ can occur at some frequency without resonance absorption. It is suggested that the σ/frequency curve be used as a criterion of resonance.

621.315.612.4 708

Properties of Beryllium-Barium Titanate Dielectrics.—E. N. Bunting, G. R. Shelton, A. S. Creamer & B. Jaffe. (*Bur. Stand. J. Res.*, July 1951, Vol. 47, No. 1, pp. 15–24.) Dielectrics having compositions in the system $BeO\text{-}BaTiO_3\text{-}TiO_2$ were matured at 1 240°–1 525°C. Data are given for the composition, heat treatment, absorption and shrinkage. The dielectric constant (K) and the reciprocal of the power factor (Q) were determined at various temperatures from − 60° to 200°C; measurement frequencies used were 50 kc/s, 130 kc/s, 1 Mc/s, 20 Mc/s, and 3 kMc/s. The linear thermal expansion over the range 25°–700°C was found to vary from 0·58 to 0·77%. The resistivity at 200°C decreased in some cases by a factor of 10^5 over a few days; for specimens of some compositions K and Q changed with time. Results are tabulated.

537.525 709

Dielectric Breakdown of Solids. [Book Review]—S. Whitehead. Publishers: Oxford University Press, London, 271 pp., 25s. (*Elect. Rev., Lond.*, 27th July 1951, Vol. 149, No. 3844, p. 208.) An account of theoretical and experimental work carried out by the Electrical Research Association.

MATHEMATICS

512.972 710

Practical Transformation Methods for Tensors of the Third and Fourth Orders.—R. Bechmann. (*Arch. elekt. Übertragung*, Aug. 1951, Vol. 5, No. 8, pp. 360–362.) Methods useful in treatment of the elastic and piezoelectric properties of crystals.

517.544.2 : 621.392 711

The One-Sided Green's Function.—K. S. Miller. (*J. appl. Phys.*, Aug. 1951, Vol. 22, No. 8, pp. 1054–1057.) Discussion of the properties of the function and of its relation to the impulsive response of a linear network.

517.63 712

The Solution of Boundary-Value Problems by Multiple Laplace Transformations.—T. A. Estrin & T. J. Higgins. (*J. Franklin Inst.*, Aug. 1951, Vol. 252, No. 2, pp. 153–167.)

517.944 713

Solutions of Some Partial Differential Equations (with Tables).—L. Weinberg. (*J. Franklin Inst.*, July 1951, Vol. 252, No. 1, pp. 43–62.) Discussion, exemplification and tabulation of the solutions of Laplace's equation, Poisson's equation, the diffusion equation, the wave equation, the damped-wave equation and Helmholtz's equation.

518.3 714

Construction of Three-Dimensional Nomographs.—W. H. Burrows. (*Industr. Engng Chem.*, Aug. 1951, Vol. 43, No. 8, pp. 1823–1826.) A simple theoretical approach is presented, applicable to all formulae capable of representation in a nomogram with a planar index surface; the construction is made on a hyperbolic co-ordinate system.

519.2 : 621.396.822 715

Expected Number of Crossings of Axis by Linearly Increasing Function plus Noise.—F. W. Lehan. (*J. appl. Phys.*, Aug. 1951, Vol. 22, No. 8, pp. 1067–1069.) "The expected number of times the function $e(t) = at + e_N(t)$ crosses the t axis in a positive direction prior to any given time is calculated, where $e_N(t)$ is a random noise function of arbitrary power spectrum. The solution is given as the product of two functions. Curves are presented for the two functions."

517 : 621.3.015.3 : 621.3 716

Transient Analysis in Electrical Engineering. [Book Review]—S. Fich. Publishers: Prentice-Hall, New York, 1951, 306 pp., $5.50. (*J. Franklin Inst.*, Aug. 1951, Vol. 252, No. 2, p. 208.) "Designed for a stiff undergraduate course." Differential equations and operational methods are used.

MEASUREMENTS AND TEST GEAR

620.178.16 : 621.315.3 717

The Testing of Fine Wires for Telecommunication Apparatus.—R. C. Woods & J. K. Martin. (*Proc. Instn elect. Engrs*, Part II, Aug. 1951, Vol. 98, No. 64, pp. 529–536. Discussion, pp. 536–538.) Existing acceptance and quality tests are discussed, abrasion and electrical breakdown are considered in greater detail and the need for new tests and for appreciation of the limitations of existing ones is stressed.

621.3.018.41(083.74) 718

Standard Frequency Transmissions.—(*Wireless World*, Sept. 1951, Vol. 57, No. 9, p. 378.) Details are given of the four standard-frequency signals radiated by the B.B.C. The 200-kc/s signal is particularly useful; guaranteed accuracy is to within 1 part in 10^6 of the nominal frequency, actual accuracy even greater. The frequency stability of the B.B.C's ordinary transmissions is also discussed briefly.

621.3.087.4 : 551.510.535 719

A 16-kW Panoramic Ionospheric Recorder.—R. Lindquist. (*Acta polyt., Stockholm*, 1951, No. 85, 41 pp.) For another account see 1425 of 1951.

621.3.087.6 : [621-526 : 621.396.615 720

A Servo Drive for Heterodyne Oscillators.—T. Slonczewski. (*Elect. Engng, N.Y.*, Aug. 1951, Vol. 70, No. 8, p. 683.) Summary of A.I.E.E. 1951 Summer General Meeting paper. A method for sweeping a test oscillator through its frequency range while some characteristic of the device under test is being recorded. The frequency varies linearly with time, which simplifies the analysis of the records.

621.316.8 : 621.396.822 721

A Low-Frequency Noise-Voltage Generator.—H. Schneider. (*Funk u. Ton*, July 1951, Vol. 5, No. 7, pp. 337–343.) Equipment is described which gives, in the frequency range 1 c/s–20 kc/s, an effective voltage of 5 V across a 600-Ω matched load. Peak noise voltages are about three times the effective values. A wire resistor serves as the noise source; the thermal noise in the range 50–90 kc/s is aperiodically amplified and then transposed to the desired range by means of a ring modulator, using an auxiliary frequency of 70 kc/s. The power-supply unit includes a Steinlein stabilization system. Full circuit details of both generator and supply unit are given.

621.317.3 : 621.396.611.21.011 722

New Methods for the Determination of Electric Constants of Vibrating Piezo-electric Crystals.—P. G. Ventouratos. (*Beama J.*, Aug. 1951, Vol. 58, No. 170, pp. 227–230.) The effective Q and R of a quartz-crystal resonator are determined (*a*) from c.r.o. measurements of the decrement of the oscillations in a circuit including the crystal, on suddenly cutting off the h.v. supply, (*b*) by bridge measurement of the equivalent shunt resistance of the crystal at resonance. The effective L and C of the crystal are then easily calculated from simple formulae.

621.317.3 : 621.396.645 723

Degree of Amplification of Amplifiers for Electrical Measurements.—F. Moeller. (*Arch. tech. Messen*, Aug. 1951, No. 187, pp. T94–T95.) Review of the characteristics of the various types of amplifier, with 29 references.

621.317.3.083.4 : 621.392 724

Double-T Networks for Null Measurements at High Frequency.—E. Samal. (*Arch. tech. Messen*, Aug. 1951, No. 187, pp. T86.) Equivalent circuits are given for various T networks, and expressions for the transfer impedance of a double-T network giving zero output voltage are derived. Circuits specially suitable for R, L or C null measurements at frequencies up to about 60 Mc/s are described and their particular advantages enumerated.

621.317.329 : 621.392.26† 725

Determination of Aperture Parameters by Electrolytic-Tank Measurements.—S. B. Cohn. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, pp. 1416–1421.) Results of measurements of magnetic polarizability are given for rectangular apertures and for slot, cross-, rosette-, dumbbell-, and H-shaped apertures with slot ends rounded.

621.317.331 726

Methods for the Measurement of Very High Electrical Resistances and Low Capacitances.—H. Tellez Plasencia. (*Rev. gén. Élect.*, May 1951, Vol. 60, No. 5, pp. 209–212.) A method for measuring resistances of the order of 10^{12} Ω uses a current which is constant and independent of voltage; this current is obtained from a saturated ion generator or the anode circuit of a diode. Voltages are measured with an electrostatic instrument. Calibration methods are discussed, a piezoelectric device may be used.

621.317.335.3 : 621.396.677 727

Artificial Dielectrics for Microwaves.—W. M. Sharpless. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, pp. 1389–1393.) Description of a procedure for measuring the permittivity and loss factor for metal-strip-loaded pseudo-dielectrics, making use of a short-circuited coaxial line. Formulae based on transmission-line theory are provided for determining approximately the dielectric properties of certain loading configurations.

621.317.336 728

A Precise Sweep-Frequency Method of Vector Impedance Measurement.—D. A. Alsberg. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, p. 1393.) An impedance is determined from the insertion loss and phase shift which result when it is inserted in a transmission line terminated at both ends by its characteristic impedance. Insertion loss and phase shift can be converted directly to impedance by use of special charts, whose derivation is outlined. Equipment previously described (2836 of 1949) has been modified and sweep-frequency measurements from 50 kc/s to 20 Mc/s can now be made with a possible accuracy to within ± 0·05% for impedances of about 75 Ω.

621.317.336 : 621.396.67 729

The Measurement of Antenna Impedance using a Receiving Antenna.—Hartig, King, Morita & Wilson. (See 585.)

621.317.336 : 621.396.676.001.57 730

The Use of Complementary Slots in Aircraft-Antenna Impedance Measurements.—Bolljahn & Granger. (See 594.)

621.317.353 731

A New Measurement Apparatus for Mains-Voltage Overtones.—W. Wilshaus. (*Elektrotech. Z.*, 1st July 1951, Vol. 72, No. 13, pp. 408–410.) An overtone-meter is described, in which the deflection of a wattmeter indicates the instantaneous amplitude of the overtones. The error may be calculated from curves or may be balanced out; in the latter case its magnitude is reduced to $<$ 1% of the measured value.

621.317.361 **732**

Frequency Measurement by the Capacitor Charge Method.—H. Weidemann. (*Arch. tech. Messen*, Aug. 1951, No. 187, pp. T87–T88.) Detailed description of the method in which an incoming sine wave, whose frequency is to be determined, is transformed into a rectangular wave by means of a multistage amplifier. This rectangular wave is differentiated, at the point where its value is zero, by an RC circuit whose time constant corresponds to the highest measurement frequency. The d.c. mean value of the capacitor charging current is then proportional to the measurement frequency. The accuracy of the method is discussed.

621.317.382 : 621.3.015.7† **733**

Measurement of Power at the Peaks of Periodic High-Frequency Pulses.—W. Hasselbeck. (*Funk u. Ton*, July 1951, Vol. 5, No. 7, pp. 344–350.) Peak pulse power is derived from mean power by use of a form factor whose physical significance is explained and for which a method of measurement is described.

621.317.382 : 621.396.611.21 **734**

Power Measurements on Ultrasonic Quartz Oscillators.—W. Schmitz & L. Waldick. (*Z. angew. Phys.*, Aug. 1951, Vol. 3, No. 8, pp. 281–288.) So that the measurements can be made during normal operation without disturbing the radiation field, an electrical method is used. This is based on a development of the equivalent circuit of the crystal, in which its equivalent resistance is resolved into three measurable components, viz., (*a*) internal resistance, (*b*) resistance due to holder, and (*c*) radiation resistance. Results are presented and discussed.

621.317.71/.72 **735**

New Moving-Coil Standard Instrument.—(*Arch. tech. Messen*, July 1951, No. 186, pp. F1.) Improvements in the AEG instrument include an Alni magnet giving a much stronger field in the gap (3 500–5 000 gauss) and a new coil system. Temperature compensation is provided. At 20°C the reading error at any point of the uniform scale in no case exceeds 0·1–0·2% of the full-scale reading.

621.317.725 **736**

Linear Diode Voltmeter. Response to Randomly Recurrent Impulses.—R. E. Burgess. (*Wireless Engr*, Nov. 1951, Vol. 28, No. 338, pp. 342–344.) "The response of an ideal linear diode voltmeter to randomly recurrent impulses is evaluated in terms of the parameters of the impulses and the time constants of the voltmeter. The rectification efficiency is shown to be slightly greater than that for regularly recurrent impulses of the same average recurrence frequency."

621.317.733 : 621.317.335.3† **737**

A Bridge for the Measurement of the Dielectric Constants of Gases.—W. F. Lovering & L. Wiltshire. (*Proc. Instn elect. Engrs*, Part II, Aug. 1951, Vol. 98, No. 64, pp. 557–563.) The criteria of sensitivity and stability required for the determination of the dielectric constants of gases are discussed; these can be met by the use of an a.c. bridge, a suitable design of which is described. Results of measurements on several gases and on water vapour are given.

621.317.755 **738**

Oscillograph with Electronic Commutator for Four Recordings.—B. Bladier. (*Rev. gén. Élect.*, May 1951, Vol. 60, No. 5, pp. 195–203.) A c.r.o. using a time-division system.

621.317.755 **739**

A Fiftyfold Momentary Beam Intensification for a High-Voltage Cold-Cathode Oscillograph.—J. H. Park. (*Bur. Stand. J. Res.*, Aug. 1951, Vol. 47, No. 2, pp. 87–93.) Circuit devices are described for superposing steeply rising voltage pulses on the steady direct voltage of 50 kV normally applied to the discharge tube producing the electron beam. The beam intensity is momentarily increased up to fiftyfold, and legible traces are obtained with writing speeds as high as 9 100 in./μs. For a shorter account see *Tech. Bull. nat. Bur. Stand.*, Oct. 1951, Vol. 35, No. 10, pp. 148–150.

621.317.755 : 621.3.012.2 **740**

Circle-Diagram Recorder for the Audio-Frequency Range.—O. Schäfer & H. Eberhardt. (*Arch. elekt. Übertragung*, Aug. 1951, Vol. 5, No. 8, pp. 377–382.) The apparatus described comprises an a.f. generator, preamplifier, ring modulator and low-pass filter, final amplifier and c.r. tube. This enables complex impedances, conductances and transformation ratios to be measured in the range 50 c/s–10 kc/s. By continuous variation of a parameter, generally the frequency, the circle diagram can be displayed, compared with a standard curve and photographed. Parts of the equipment are suitable for measurements on complex impedances or can be used as a complex compensator.

621.317.755 : 621.397.5 **741**

Oscillographic Representation of Television Signals.—K. R. Sturley. (*Radio tech. Dig., Édn franç.*, 1951, Vol. 5, Nos. 4 & 5, pp. 227–235 & 289–292.) French version of 447 of February.

621.317.757 **742**

Result of Measurements on the Rounded-Signal [radiotelephony] **Transmitter at Lyon-la-Doua.**—A. Tchernicheff. (*Ann. Télécommun.*, July 1951, Vol. 6, No. 7, pp. 191–196.) Measurements were made with the spectrometer previously described (3056 of 1951) (*a*) to study the use of the instrument, (*b*) to examine the performance of the transmitter, and (*c*) to investigate generally the restriction of spectra. Results are illustrated by oscillograms and periodograms of various signals.

621.317.761 **743**

Accurate Direct-Reading Frequency-Measurement Equipment, 30 c/s–30 Mc/s.—L. R. M. Vos de Wael. (*Tijdschr. ned. Radiogenoot.*, July 1951, Vol. 16, No. 4, pp. 171–184.) The equipment consists essentially of a multivibrator circuit fed from a 100-kc/s standard source and providing multiples of 1 Mc/s up to 29 Mc/s, a mixing circuit, and an electronic counter ranging from 30 c/s to 1 Mc/s. Results are given directly on the counter and on the single knob controlling the selection of a suitable harmonic. Accuracy of measurement is of the order of 1 part in 10^7, $\pm$ 1 c/s.

621.317.763.029.64 **744**

Design of Cavity-Resonator Wavemeters for Cm Waves.—M. L. Toppinga. (*Tijdschr. ned. Radiogenoot.*, July 1951, Vol. 16, No. 4, pp. 185–207.) A graphical method of deriving design data is described and is applied to the design of a cavity wavemeter for the 5–7-cm band. The elimination of unwanted modes is discussed and the method of calibration is described. The accuracy achieved is of the order of 1 part in 1 000.

621.396.621 : 621.396.619.13 **745**

A New Method for Predicting the Adjacent-Channel Performance of Mobile Radio Equipments by Graphical

Analysis.—T. S. Eader. (*FM-TV*, Sept. 1951, Vol. 11, No. 9, pp. 21–24..39.) Various methods of testing the selectivity of f.m. communication receivers are discussed; the I.R.E. method is preferred, in which two modulated signals are applied simultaneously, one signal having a desired carrier frequency and the other a frequency adjustably spaced from the first. To determine for a given receiver whether interference will be caused first by (*a*) break-through of adjacent-channel modulation, (*b*) desensitization produced by the adjacent-channel carrier or (*c*) on-frequency noise produced by the adjacent-channel transmitter, a three-stage graphical procedure is developed comprising (*a*) preparation of transmitter sideband distribution curves, (*b*) preparation of receiver interference characteristics and (*c*) graphical application of curves (*a*) to curves (*b*). Methods are also given for the measurement of bandwidth, which should be specified separately from selectivity.

621.317.3.029.5/.6 **746**

High-Frequency Measurements. [Book Review]—A. Hund. Publishers: McGraw-Hill, New York, 2nd edn 1951, 631 pp., $10.00. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, p. 1472.) "This second edition . . . has been revised extensively . . . 'High frequency' now is interpreted to include all frequencies above 20 kilocycles per second up to super high frequencies (microwaves) . . . With this timely revision, the book will retain its leadership in the frequency range of greatest interest to practical radio engineers."

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

531.768 : 546.431.824-31 **747**

Miniature Piezoelectric Accelerometer.—(*Tech. Bull. nat. Bur. Stand.*, Oct. 1951, Vol. 35, No. 10, pp. 141–142.) The device described is intended for direct measurement of mechanical vibrations and for testing the frequency response of vibration generators. The pickup comprises a $BaTiO_3$ disk of thickness $\frac{1}{16}$ in. and diameter $\frac{3}{8}$ in., stacked between a base and a metal loading block; it weighs $< 0{\cdot}1$ oz. The response curve is flat within 20% between 50 c/s and 6 kc/s, and rises to a slight peak between 10 and 18 kc/s.

531.768 : 546.431.824-31 **748**

Self-Generating Accelerometers.—G. K. Guttwein & A. I. Dranetz. (*Electronics*, Oct. 1951, Vol. 24, No. 10, pp. 120–123.) The characteristics and advantages are discussed of compression and bending types of accelerometer using piezoelectric $BaTiO_3$ ceramic elements. The useful range of a typical unit is from $0{\cdot}022\,g$ to $600\,g$; the corresponding output-voltage range of 1 mV–27 V can be measured with normal equipment. Readings are hardly affected by temperature or humidity.

538.569.2.047 **749**

Dielectric Behaviour of Human Blood at Microwave Frequencies.—H. F. Cook. (*Nature, Lond.*, 11th Aug. 1951, Vol. 168, No. 4267, pp. 247–248.) Measurements of the dielectric constant of human blood over the frequency range $1{\cdot}78 \times 10^9$–$2{\cdot}36 \times 10^{10}$ c/s are reported; coaxial-line and waveguide methods were used. Experimental results are discussed in relation to dielectric theory.

620.178.3 **750**

Electrically Excited Resonant-Type Fatigue Testing Equipment.—T. J. Dolan. (*ASTM Bull.*, July 1951, No. 175, pp. 60–68.) An application of a valve-maintained tuning-fork circuit, with electronic calibration and control.

620.179.16 **751**

Supersonic Flaw Detection.—(*Overseas Engr*, Aug. 1951, Vol. 25, No. 284, pp. 32–34.) Description of two British commercial equipments, with details of the various probes available.

621.315.612.4 : 546.431.824-31 **752**

An Electrostatically Induced Permanent Memory.—C. F. Pulvari. (*J. appl. Phys.*, Aug. 1951, Vol. 22, No. 8, pp. 1039–1044.) The possibility of using a ferroelectric substance ($BaTiO_3$) as a medium for storing information is discussed. Preliminary experiments were performed to determine the necessary conditions for inscribing and erasing electrostatic preorientation in $BaTiO_3$ ceramics at a temperature somewhat below the Curie point. The results suggest the possibility of a memory device that can be operated in the range of audio frequencies or higher.

621.317.755 : 612.82 **753**

A Toposcopic Display System applied to Neurophysiology.—W. Grey Walter & H. W. Shipton. (*J. Brit. Instn Radio Engrs*, July 1951, Vol. 11, No. 7, pp. 260–273.) Simultaneous records of the electrical activity in a region containing spaced signal sources, e.g., the brain, are visually displayed on a system of 22 c.r. tubes arranged to represent a simple map of the brain. The design of the electronic equipment is discussed. Records are shown illustrative of the application to the electroencephalographic problems of the distribution and frequency of normal rhythm, the location of abnormal activity, and the geometry and frequency of the electrical responses evoked by photic stimulation.

621.317.755 : 621.4 **754**

The Standard-Sunbury Engine Indicator 'Mark 6'.—E. S. L. Beale & R. Stansfield. (*Engineer, Lond.*, 17th & 24th Aug. 1951, Vol. 142, Nos. 4986 & 4987, pp. 215–217 & 246–248.) A detailed description of an improved c.r.o. engine indicator. The pickup heads are of an electromagnetic type with good high-frequency response. The timing errors introduced by the crankshaft degree-marker wheel and by the amplifier response have been reduced to $<0{\cdot}1°$ at 6 000 r.p.m. Switching between different pickups and the degree marker is instantaneous, with no float of the base line.

621.365.54/.55† **755**

Radio Frequency Heating in Industry.—R. Smith. (*G.E.C. J.*, July 1951, Vol. 18, No. 3, pp. 157–168.) The characteristic features of dielectric and induction heating are described and industrial applications are indicated; rates of energy transfer obtained with r.f. heating are compared with those obtained by other methods.

621.365.54/.55† **756**

Matching Problem, Efficiency and Recent Applications of High-Frequency Heating.—R. Wälchli. (*Bull. schweiz. elektrotech. Ver.*, 28th July 1951, Vol. 42, No. 15, pp. 525–531. In German.) A simple formula for the efficiency of the inductive heating of metals is derived and the calculation of the matching of the work to the h.f. generator is explained. From the formula the effect of the various factors concerned in the design of the work coil is discussed. Examples of recent applications of both inductive and capacitive heating are described.

621.365.54/.55† **757**

Application of Tubes in Heating Equipment.—H. J. Dailey & C. H. Scullin. (*Electronics*, Oct. 1951, Vol. 24, No. 10, pp. 216 . . 240.) Discussion of the physical and electrical factors concerned in obtaining maximum service from valves used in h.f.-heating generators.

621.38.001.8 758

Applied Electronics.—C. A. Taylor. (*Nature, Lond.*, 18th Aug. 1951, Vol. 168, No. 4268, pp. 283–284.) Brief description of wide variety of electronic devices exhibited at Manchester College of Technology, July 1951.

621.384.6† : 621.313.291 759

Pulsed Air Core Series Disk Generator for Production of High Magnetic Fields.—R. I. Strough & E. F. Shrader. (*Rev. sci. Instrum.*, Aug. 1951, Vol. 22, No. 8, pp. 578–582.) A device is described which can store a large quantity of energy efficiently in the form of kinetic energy of rotation, and convert it rapidly into useful electromagnetic energy by using the rotating mass as the armature of a series-wound homopolar generator. When operated under short-circuit conditions, a current pulse of 56 kA maximum is obtained in the single-turn series field coil. Generators of this type may be useful as sources of magnetic field for air-core betatrons and synchrotrons.

621.384.6 : 621.316.721 760

Magnet Current Stabilizer.—H. S. Sommers, Jr, P. R. Weiss & W. Halpern. (*Rev. sci. Instrum.*, Aug. 1951, Vol. 22, No. 8, pp. 612–618.) Design and performance of a feedback amplifier for controlling the current of a 40-kW electromagnet are described; fluctuations at frequencies $> 10^{-3}$ c/s are kept below 1 part in 10^6.

621.384.611.2† 761

Forced Betatron Oscillation in a Synchrotron with Straight Sections.—N. M. Blachman. (*Rev. sci. Instrum.*, Aug. 1951, Vol. 22, No. 8, pp. 569–571.)

621.384.612.1† 762

A Dee Biasing System for a Frequency Modulated Cyclotron.—L. L. Davenport, L. Lavetelli, R. A. Mack, A. J. Pote & N. F. Ramsey. (*Rev. sci. Instrum.*, Aug. 1951, Vol. 22, No. 8, pp. 601–604.)

621.385.833 763

Spherical-Aberration Correction of Electron Lenses by means of Image-Forming Elements without Rotational Symmetry.—R. Seeliger. (*Optik*, July 1951, Vol. 8, No. 7, pp. 311–317.)

621.385.833 764

55-kV Electron Microscope.—(*Engineer, Lond.*, 31st Aug. 1951, Vol. 192, No. 4988, pp. 266–268.) An instrument suitable for routine examination of specimens. It uses three image-forming lenses and a fourth lens to control the electron beam intensity. The 55-kV electron-gun supply is given by an air-insulated h.f. d.c. source and is stabilized to within 4 V. Magnifications up to 12 000 times can be attained. The specified resolving power of the Type-EM4 is better than 100 Å.

621.387.4† 765

Radiation and Particle Detectors in Modern Nucleonic Instruments.—D. Taylor. (*J. Brit. Instn Radio Engrs*, July 1951, Vol. 11, No. 7, pp. 247–259.) A review of electronic measuring instruments used to monitor the emission of short-wave radiation and charged or uncharged particles, with particular emphasis on their long-term stabilities. A typical process-control instrument is described which has an accuracy to within $\pm 1\%$ over long periods, for the continuous routine control of α particles in solutions.

621.387.424† 766

The Slow Discharge in a Non-Self-Quenching Geiger-Mueller Counter.—W. E. Ramsey. (*J. Franklin Inst.*, Aug. 1951, Vol. 252, No. 2, pp. 143–151.)

621.387.424† 767

The Gas Filling and some Characteristics of Bromine-Quenched Geiger-Müller Counters.—D. H. Le Croissette & J. Yarwood. (*J. sci. Instrum.*, Aug. 1951, Vol. 28, No. 8, pp. 225–228.)

621.387.424† 768

A Toroidal Geiger Counter.—C. P. Haigh. (*Nature, Lond.*, 11th Aug. 1951, Vol. 168, No. 4267, pp. 246–247.) Description of an experimental counter constructed to give sensitivity nearly independent of source position over a limited region.

621.387.462† 769

Ionization Pulses and Charge Transport Mechanism in Diamond.—H. Ess & J. Rossel. (*Helv. phys. Acta*, 10th July 1951, Vol. 24, No. 3, pp. 247–278. In French.)

621.398 770

Radio Telearchics.—(*Wireless World*, Sept. 1951, Vol. 57, No. 9, pp. 342–346.) Systems are discussed for the remote control of apparatus by radio, with particular reference to the control of aircraft and boats. Methods for transmitting instructions of both on-off and continuous-control types are considered; radio aspects are examined, and electromechanical equipment at the receiver is described. See also 1747 of 1951 (Lankester & Dreier).

621.398 : 621.396.712 771

Remote-Control System for F.M. Broadcast Stations.—P. Whitney. (*Tele-Tech*, Aug. & Sept. 1951, Vol. 10, Nos. 8 & 9, pp. 32–35 . . 78 & 44–45, 80.) Description, with detailed circuit diagrams, of a system in use at Winchester, Va., for controlling and monitoring an unattended broadcasting transmitter over 20 miles away. Six tones in the range 18–30 kc/s, applied at a low modulation level to the auxiliary transmitter linking the studio to the remote transmitter, are used for control purposes. In the monitoring equipment the sampling voltages derived from the meter readings are used to modulate a 30-kc/s subcarrier which, in turn, modulates the f.m. broadcasting transmitter to a degree not $>5\%$. A special receiver in the studio is tuned to the subcarrier to derive all meter readings.

621.791.3 : 535.61-1 772

Electronic Control of Soldering Temperatures by Infrared Radiation.—Déribéré & J. C. Stern. (*Électronique, Paris*, Aug./Sept. 1951, Nos. 57/58, pp. 4–7.) The radiation from the work pieces is interrupted by the teeth of a rotating wheel and then falls on a compensated bolometer. The resulting modulated signal is amplified and used to control the heating system.

PROPAGATION OF WAVES

538.566 773

The Zenneck Ground Wave.—G. Goubau. (*Z. angew. Phys.*, March/April 1951, Vol. 3, Nos. 3/4, pp. 103–107.) Analysis showing that the Zenneck wave is physically possible; the problem is analogous to that of the excitation of an open waveguide. There is an orthogonal relation between the ground wave and the space wave, from which the amplitude of the former can be calculated.

538.566 774

Propagation in a Non-homogeneous Atmosphere.—Friedman. (See 661.)

538.566 : 535.13 775

Field Representations in Spherically Stratified Regions.—Marcuvitz. (See 663.)

621.396.11 + 621.396.671 **776**

Application of the Compensation Theorem to Certain Radiation and Propagation Problems.—Monteath. (See 591.)

621.396.11 : 538.566 **777**

The Ground Wave of a Transmitter.—H. Ott. (*Z. angew. Phys.*, March/April 1951, Vol. 3, Nos. 3/4, pp. 123–134.) An analysis of the field radiated from conducting and dielectric surfaces. The ground wave is affected by the existence of the Schmidt 'head wave' (3117 of 1949), which takes energy from it; this, and not ground absorption, is the main reason for the rapid attenuation of the ground wave. The electric and magnetic field strengths within the ground wave are investigated, together with the phase relations for any values of ground constants. The greatest height of the mean downward-curved energy flux, which gives a quantitative indication of range of the wave in free space, is determined for the whole of the field.

621.396.11 + 538.566] : 550.38 **778**

The Effect of the Earth's Magnetic Field on Short-Wave Communication by the Ionosphere.—G. Millington. (*Proc. Instn elect. Engrs*, Part IV, Oct. 1951, Vol. 98, No. 1, pp. 1–14.) Summary abstracted in 2805 of 1951.

621.396.11 : 551.510.535 **779**

Scattering of Radio Waves and Undulation in the Ionosphere.—S. S. Banerjee, R. R. Mehrotra & V. D. Rajan. (*Sci. Culture*, July 1951, Vol. 17, No. 1, pp. 45–46.) Reception of scattered echoes from the F region, using low-power pulse ionospheric sounding equipment, is described. Scattering of the ordinary ray occurred at frequencies immediately below the penetration frequency, and is attributed to the presence of irregularities at the level to which the rays penetrated.

621.396.11 : 551.510.535 **780**

Spectral Representation of Space-Wave Reception and the Ionosphere.—A. Spork. (*Öst. Z. Telegr. Teleph. Funk Fernsehtech.*, July/Aug. 1951, Vol. 5, Nos. 7/8, pp. 100–110.) An account of the formation and structure of the ionosphere and its influence on radio propagation, illustrated by records of reception obtained with wide-band apparatus developed by Herzan.

621.396.11 : 551.510.535 **781**

Influence of the Earth's Magnetic Field on Group Velocity and Propagation Time of Radio Waves in the Ionosphere.—H. Poeverlein. (*Z. angew. Phys.*, March/April 1951, Vol. 3, Nos. 3/4, pp. 135–143.) The vertical component of group velocity of a reflected wave is determined theoretically, assuming a plane ionosphere and linear ionization gradient. At vertical incidence, compared with velocities in the absence of the earth's field the velocity of the extraordinary wave is less while that of the ordinary wave is greater over part of its path and less over another part. At oblique incidence, in the region of reflection for steeply incident rays the vertical component of velocity increases with increasing angle of incidence. Comparison of critical frequencies for the ordinary wave at vertical and oblique incidence under certain conditions may provide a test for the validity of the theoretical conclusions.

621.396.11 : 551.510.535 **782**

Some Calculations of Ray Paths in the Ionosphere.—S. K. H. Forsgren. (*Acta polyt., Stockholm*, 1951, No. 85, 23 pp.) The refractive index for the ordinary and the extraordinary ray has been computed as a function of direction, for some cases frequently met with, taking account of the influence of electronic collisions on the curve form. With the aid of a graphic method due to Poeverlein (2875 of 1950), ray paths have been calculated for vertical incidence, zero losses, and a parabolic electron-density distribution. Approximate formulae are given for the horizontal deviation of the ordinary and extraordinary rays for vertical incidence. Maximum deviation occurs for frequencies near the critical frequency of the layer and may be large enough to make any determination of gyrofrequency from critical-frequency measurements unreliable.

621.396.11 : 551.510.535(98) **783**

Polar Blackouts recorded at the Kiruna Observatory.—R. Lindquist. (*Acta polyt., Stockholm*, 1951, No. 85, 25 pp.) Report and discussion of observations, beginning in October 1948, with a panoramic recorder covering the range 1–16 Mc/s in 30 sec. The results obtained indicate that polar blackouts are due to the impact of some ionizing agent. This view is supported by the close correlation between blackouts, magnetic disturbances, aurorae, and the appearance of a certain type of sporadic-E reflection (termed N1), and also by the increase of F_2-layer ionization frequently noted immediately after a blackout. The diurnal distribution of blackouts is similar to that of the current in the auroral zone. There is a tendency for blackouts to recur at about the same time on two or more successive days. This may be of nterest in the prediction of propagation conditions.

621.396.11 : 621.317.087.4 **784**

Notes on the Analysis of Radio-Propagation Data.—R. P. Decker. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, pp. 1382–1388.) Statistical analysis of observations on the propagation of 410-Mc/s signals over distances of 86 and 134 miles. The equipment for indicating the percentage of time for which a number of pre-selected signal levels were exceeded is described.

621.396.11 : 621.317.353.3† **785**

Ionospheric Cross-Modulation.—I. J. Shaw. (*Wireless Engr*, Nov. 1951, Vol. 28, No. 338, pp. 335–342.) A survey of the theory of cross modulation and of recent experimental work. The experimental technique for the measurement of the amplitude and phase of the modulation transferred to the wanted carrier is described and details of the equipment are given. From measurements using several pairs of B.B.C. stations, a value for the collision frequency was derived. Experimental confirmation was obtained of the laws of variation of cross modulation with (*a*) modulation frequency, (*b*) radio frequency, (*c*) power, (*d*) modulation depth of the disturbing wave. Variations at sunrise were contrary to expectations. Self-distortion due to the frequency-dependent absorption of energy by the ionosphere is also discussed.

621.396.11.029.45 **786**

The Reflection of Very-Low-Frequency Radio Waves at the Surface of a Sharply Bounded Ionosphere with Superimposed Magnetic Field.—K. G. Budden. (*Phil. Mag.*, Aug. 1951, Vol. 42, No. 331, pp. 833–850.) A homogeneous ionosphere is assumed. The quasi-longitudinal approximation to the magneto-ionic theory [3306 of 1935 (Booker)] is used, the reflection coefficients being then independent of the horizontal direction of the transmission path. Values derived from the theory are compared with the experimental observations reported in 2522 of 1951 (Bracewell et al.). There is some qualitative agreement for frequencies of 16 kc/s and above, but the theory is likely to be most useful for investigating propagation at frequencies of 10 kc/s and below, used in studying atmospherics.

621.396.11.029.62 **787**

Radio Propagation Experiments carried out between Monte Serpeddi (Cagliari) and Monte Cavo (Rome) on

Metre Wavelengths during the Period January–May 1949.—A. Ascione & C. Micheletta. (*Poste e Telecomunicazioni*, May 1951, Vol. 19, No. 5, pp. 251–262.) A full description is given of the transmitting and receiving gear for this 33-Mc/s link, and of the precautions taken to ensure that the various parts of the system operated under known and stable conditions. The path is 392 km long, almost entirely over sea, and 170 km of it lies outside the optical range. The recording programme was so planned that sample coverage for all hours of the day and night was obtained. Three main types of record could be distinguished: (*a*) constant-level, associated with very fine, calm weather; (*b*) slowly fluctuating, associated with unsettled weather; (*c*) rapidly and irregularly fluctuating, during or immediately preceding and following showers of hail or snow. Anticyclones were characterized by high-level signals. The passage of a cold front followed by a warm belt led to a slow decrease followed by a rapid rise in signal intensity. Observations during fog agreed with those reported in 2061 of 1948 (Smith-Rose & Stickland), while wind always adversely affected the signal. In general the practical results obtained were very much better than those expected from theoretical calculations. The experiments are being continued.

621.396.11.029.63 **788**

Propagation at 412 Mc/s from a High-Power Transmitter.—I. H. Gerks. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, pp. 1374–1382.) "Extended measurements are reported which indicate the existence of pronounced nocturnal superrefraction during an appreciable percentage of the summer and of very persistent scattering by atmospheric turbulence near the surface in all seasons. The measurements were taken over rolling midwestern terrain at a distance of about 100 miles. Mobile road tests were made to supplement the fixed-point measurements and to provide an approximate indication of the relation between field strength and distance. Aerial tests were made to show the effects of antenna height at large distance. Graphs are provided which show the effects of distance, terrain, antenna height, and time upon the field strength. The practical significance of the results in the broadcast and communication fields is indicated."

621.396.11.029.64 **789**

Microwave Propagation in the Optical Range.—O. F. Perers, B. K. E. Stjernberg & S. K. H. Forsgren. (*Acta polyt., Stockholm*, 1951, No. 87, 20 pp.) A report of observations of transmissions from Mosseberg, Gothenburg, on wavelengths of 10, 3 and 1 cm. The transmitter height was 105 m, the altitude of the 10-cm and 3-cm receivers being 50 m and that of the 1-cm receiver 55 m, the respective ranges being 13·5 and 6·5 km, so that both paths were well within the optical range. Results are shown graphically and interesting cases of attenuation due to rain and snow, of refraction effects, and of parallel and antiparallel X-band and S-band fading, are discussed.

RECEPTION

519.241.1 : [534.874.1 + 621.396.621 **790**

Perturbation and Correlation Methods for Enhancing the Space Resolution of Directional Receivers.—F. V. Hunt. (*Proc. Inst. Radio Engrs*, July 1951, Vol. 39, No. 7, p. 840.) An assessment is made of the application of techniques for correlation with respect to space variables as well as with respect to the time variable. A simple example illustrates the use of the technique.

621.396.[397].6 **791**

40th Paris Fair.—(*Radio prof., Paris*, May 1951, No. 195, pp. 17–27.) Illustrated description of radio and television receivers exhibited. For other accounts see *T.S.F. pour Tous*, June 1951, Vol. 27, No. 272, pp. 213–217 and *Toute la Radio*, June 1951, No. 156, pp. 168–170.

621.396.621 : 621.396.619.13 **792**

A New Method for Predicting the Adjacent-Channel Performance of Mobile Radio Equipments by Graphical Analysis.—Eader. (See 745.)

621.396.621.029.63 **793**

Receivers for Use at 460 Mc/s.—E. G. Hamer & L. J. Herbst. (*Wireless Engr*, Nov. 1951, Vol. 28, No. 338, pp. 323–329.) A discussion of design considerations with particular reference to receiver signal/noise ratio. The performance of valves and circuits both as r.f. and as i.f. amplifiers is discussed. Circuits are shown of (*a*) a low-noise i.f. amplifier used for determining noise-factor data (tabulated for various valve types), (*b*) a typical receiver comprising earthed-grid r.f. amplifier and earthed-grid mixer.

621.396.621.53 **794**

Gated-Beam Mixer.—S. Rubin & G. E. Boggs. (*Electronics*, Oct. 1951, Vol. 24, No. 10, pp. 196 . . 212.) Discussion of the use of a Type-6BN6 valve as a mixer, preferably with outer-grid injection, the oscillator being connected to the third grid. Performance is satisfactory, in view of high transconductance, low space-charge coupling and low capacitance between control grids.

621.396.622 **795**

The Relative Advantages of Coherent and Incoherent Detectors: A Study of their Output Noise Spectra under Various Conditions.—R. A. Smith. (*Proc. Instn elect. Engrs*, Part IV, Oct. 1951, Vol. 98, No. 1, pp. 43–54.) Summary abstracted in 255 of January.

621.396.822 : 519.272.119 **796**

Study of some Statistical Patterns relative to Problems of Background Noise.—A. Blanc-Lapierre. (*Rev. sci., Paris*, May/June 1951, Vol. 89, No. 3311, pp. 139–150.) The identity of the variable ν in the integral expressing the theorem of Loève with the physical concept of frequency is noted. Spectral distribution of mean noise power in an amplifier is shown to correspond with a correlation function. Amplifier noise is treated theoretically with reference to a Poisson distribution, and two main spectra are identified; these are associated with flicker effect and with shot effect.

STATIONS AND COMMUNICATION SYSTEMS

621.39.001.11 **797**

Time and Frequency Uncertainty in Waveform Analysis.—P. M. Woodward. (*Phil. Mag.*, Aug. 1951, Vol. 42, No. 331, pp. 883–891.) "The concept of a structural time-constant is introduced by considering the time auto-correlation function of any waveform, and a structural frequency-constant is similarly defined in terms of the spectral auto-correlation function. By setting up a combined time and frequency auto-correlation function χ, an absolute time-frequency constant is obtained. Its value is always unity, and it is suggested that this expresses time and frequency uncertainty more precisely than the relation $\delta t.\delta f \geqslant 1/4\pi$. To illustrate the function χ, two special waveforms are considered, namely, the complex Gaussian pulse and the real Gaussian pulse-train."

621.395.97 **798**

An 8-Channel Transmitter for an Experimental Carrier Wire-Broadcasting System.—R. G. Kitchenn. (*J. Brit. Instn Radio Engrs*, Aug. 1951, Vol. 11, No. 8, pp. 295–337. Discussion, pp. 338–339.) The electrical and mechanical features are described of a transmitter which provides eight carrier frequencies evenly spaced between 55 kc/s and 209 kc/s, at a level of 100 mV on each channel. The system is suitable for broadcasting over the existing telephone network. Test equipment, audio and visual monitoring facilities, and power supplies are incorporated. A selective alarm system in conjunction with unit construction facilitates maintenance. Circuit and performance details are given.

621.396.324 **799**

Transmitter Diversity applied to Machine Telegraph Radio Circuits.—G. E. Hansell. (*Telegr. Teleph. Age*, Aug. 1951, Vol. 69, No. 8, pp. 12–14 . . 27.) Tests have shown that transmitter diversity is as effective in overcoming fading effects as receiver diversity. The system described used two transmitting aerials 1 500 ft apart, radiating at 15·49 Mc/s, the respective carriers being separated by 200 c/s; frequency-shift modulation was applied. Arrangements were made for having both transmitters, or one only, operative during alternate 5-minute periods. The results for reception in New York of signals from California showed a gain of from 12 to 30 db in favour of the diversity arrangement. The system has many applications where receiver diversity is impracticable or uneconomical.

621.396.4 **800**

Some Trends in Development in the Transmission of Information.—H. F. Mayer & E. Hölzler. (*Frequenz*, June 1951, Vol. 5, No. 6, pp. 156–166.) Review of wide-band carrier-current and directional radio systems, and of the applications of v.h.f. and u.h.f. techniques in multichannel communication.

621.396.44 : 621.315.052.63] + 621.317.083.7 **801**

Single-Sideband Equipment and High-Speed Cyclic Telemetry for Carrier-Current Operation on High-Voltage Lines.—H. Bloch. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st Aug. 1951, Vol. 29, No. 8, pp. 298–305. In French and German.) Description of Brown Boveri equipment exhibited at the 1951 Swiss Fair in Basle.

621.396.619.11 + 621.396.619.13 **802**

The Distribution of Energy in Randomly Modulated Waves.—D. Middleton. (*Phil. Mag.*, July 1951, Vol. 42, No. 330, pp. 689–707.) The theory of f.m. and ph.m. by normal random noise is developed, as a model for speech-modulated carriers. The effect of spectral shape of the modulating noise on the intensity distribution of the modulated carrier is considered, and it is found that the lowest-frequency components of the modulation are most significant. The limiting cases of very slow frequency deviation are specially considered and it is found that such adiabatic sweeps spread the original spectrum. The parallel case of a.m. by normal random noise is similarly discussed, including the effects of possible over-modulation.

621.396.029.62/.63 **803**

The Turin-Piacenza Experimental Radio Link.—L. Pivano. (*Poste e Telecomunicazioni*, March 1951, Vol. 19, No. 3, pp. 170–178.) Turin is linked by cable to the Pino Observatory, the site of one terminal, the other being at Rocca di Stradella, which was originally linked by wire to Piacenza, but is being developed as a repeater station. A further extension of the link from Rocca di Stradella to Milan is under construction. Working frequencies are: Turin–Rocca di Stradella, 160 and 174 Mc/s; Rocca di Stradella–Piacenza, 620 and 680 Mc/s; Rocca di Stradella–Milan, 650 and 690 Mc/s. Eight-channel multiplex operation as part of the public telephone service is either already taking place or envisaged for both branches. Details of equipment, planning and operational experience are given.

621.396.65.029.63 **804**

The Parameters of a Decimetre-Wave System with Pulse-Time Modulation (Pulse-Phase Modulation).—K. O. Schmidt. (*Fernmeldetech. Z.*, August 1951, Vol. 4, No. 8, pp. 362–368.) A diagram based on resistance noise shows necessary signal levels throughout the communication chain. The attainment of these values in a p.m. system, possible improvements in gain, and reduction of attenuation losses, are discussed with reference to the loss characteristics of coaxial cables, waveguides and the transmission path.

621.396.7(45) **805**

Present and Planned Broadcasting Service for Italy.—G. Provenza. (*Poste e Telecomunicazioni*, July 1951, Vol. 19, No. 7, pp. 343–346.)

621.396.712 : 621.396.66 **806**

Automatic Broadcast Program Monitor.—A. A. McK. (*Electronics*, Oct. 1951, Vol. 24, No. 10, pp. 124–127.) See also 1491 of 1951 (Rantzen, Peachey & Gunn-Russell).

621.396.712 : 621.396.66 **807**

A Supervisory Instrument for Standard Broadcast Stations.—E. D. Cook & H. R. Summerhayes, Jr. (*Gen. elect. Rev.*, July 1951, Vol. 54, No. 7, pp. 29–36.) Details are given of a multi-purpose instrument for monitoring the carrier level, frequency and modulation characteristics of a.m. broadcast stations over a wide range of input voltages with good accuracy.

621.396.712 : 621.398 **808**

Remote-Control System for F.M. Broadcast Stations.—Whitney. (See 771.)

621.396.712 (083.81) **809**

Guide to Broadcasting Stations. [Book Notice]—Publishers: *Wireless World*, Dorset House, Stamford Street, London, S.E.1, 6th edn, 94 pp., 2s. (*Wireless Engr*, Nov. 1951, Vol. 28, No. 338, p. 349.) Includes frequencies and other details of European stations and of s.w. broadcasting stations in 117 countries.

SUBSIDIARY APPARATUS

621-526 **810**

Combination Open-Cycle Closed-Cycle [control] **Systems.**—J. R. Moore. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, pp. 1421–1432.)

621-526 **811**

A General Theory of Sampling Servo Systems.—D. F. Lawden. (*Proc. Instn elect. Engrs*, Part IV, Oct. 1951, Vol. 98, No. 1, pp. 31–36.)

621.314.263 **812**

Study of Harmonic Power Generation.—P. E. Russell & H. A. Peterson. (*Elect. Engng, N.Y.*, Aug. 1951, Vol. 70, No. 8, p. 690.) Summary of A.I.E.E. Great Lakes Meeting paper, May 1951. A harmonic power generator may consist of an iron-cored reactor, to which a sinusoidal voltage is applied, followed by circuits which select the derived harmonic. Such a circuit has been analysed on a differential analyser.

621.314.634 **813**

Recovery of Selenium Rectifiers after a Voltage Pulse in the Blocking Direction.—K. Lehovec. (*J. appl. Phys.*, July 1951, Vol. 22, No. 7, pp. 934–939.) The effect of the voltage pulse is to decrease temporarily the capacitance of the rectifier. Recovery to the original capacitance value is investigated as a function of pulse height, pulse duration, and temperature. Increase of recovery speed under illumination indicates that the process is electronic and not ionic.

621.316.722 **814**

General Theory of Voltage Stabilizers.—J. J. Gilvarry & D. F. Rutland. (*Rev. sci. Instrum.*, July 1951, Vol. 22, No. 7, pp. 464–468.) The general linear voltage stabilizer can be represented by an active four-terminal network specified by four parameters. Methods of calculating stabilizer performance are given which require four independent measurements; knowledge of the stabilizer circuits is unnecessary. The theory is confirmed by experiment on a degenerative stabilizer for which the approximations of the three-parameter theory are considerably in error.

621.316.933.3 **815**

Latest Developments in the Design of Resorbit Arresters.—W. Zoller. (*Brown Boveri Rev.*, April 1951, Vol. 38, No. 4, pp. 105–114.) Arresters are now produced with a rated discharge capacity of 5–10 kA and a maximum discharge capacity 20 times greater, and the Resorbit resistance material can now cope with low lightning currents of long duration as well as with h.v. surges. Different types now available are illustrated and the effects of rain, fog, external capacitance to earth, and steep-fronted waves, are considered.

621-526 **816**

Servomechanisms and Regulating System Design. [Book Review]—H. Chestnut & R. Mayer. Publishers: J. Wiley & Sons, New York, 1951, 505 pp., $7.75. (*J. Franklin Inst.*, July 1951, Vol. 252, No. 1, p. 96.) "This book . . . is intended for the training of design and application engineers in the principles of feedback control."

TELEVISION AND PHOTOTELEGRAPHY

621.396.[397].6 **817**

40th Paris Fair.—(See 791.)

621.397 **818**

Phototelegraphy by Wire.—V. Castell. (*Tech. Mitt. schweiz. Telegr.-Teleph Verw.*, 1st Aug. 1951, Vol. 29, No. 8, pp. 309–312.) French version of paper abstracted in 3123 of 1951.

621.397.2 : 621.396.65 **819**

The Paris-Lille Television Radio-Relay Link.—(*Radio franç.*, May 1951, No. 5, pp. 6–10; *Télévis. franç.*, June 1951, No. 71, pp. 7–10, 15.) Brief illustrated description of the system. The 210-km path is covered in three stages. The Eiffel Tower transmitter radiates the f.m. video signal on 945 Mc/s ± 15 Mc/s from a dipole with parabolic reflector. The reradiated frequencies at the two relay stations are respectively 910 and 945 Mc/s, an i.f. of 85 Mc/s serving for signal amplification prior to retransmission at the higher frequency.

621.397.2 : 621.396.65 **820**

The London-Birmingham Television Radio-Relay Link.—R. J. Clayton, D. C. Espley, G. W. S. Griffith & J. M. C. Pinkham. (*Proc. Instn elect. Engrs*, Part I, July 1951, Vol. 98, No. 112, pp. 204–223. Discussion, pp. 224–227. Summary, *ibid.*, Part III, July 1951, Vol. 98, No. 56, pp. 472–476.) A comprehensive account of the complete system and its operation. See also 2026 of 1950 (Mumford & Booth) and back reference.

621.397.24/.26 **821**

Television from Calais.—W. D. Richardson & W. N. Anderson. (*J. Televis. Soc.*, April/June 1951, Vol. 6, No. 6, pp. 214–218.) A general description of preliminary tests and of the equipment used for linking Calais with London. See also 459 of 1951 (Pulling).

621.397.24 **822**

The Transmission of Television Signals on Telephone Lines.—T. Kilvington. (*J. Televis. Soc.*, Jan./March 1951, Vol. 6, No. 5, pp. 197–203.) Due to the widely varying impedance characteristics of telephone circuits, 64 constant-impedance, non-resonant equalizer sections, with fixed half-loss frequencies ranging from 15 kc/s to 4·67 Mc/s and fixed zero-frequency loss from $\frac{1}{2}$ to 3 db, are needed in each repeater unit for B.B.C. outside-broadcasts transmissions over ordinary telephone lines, in order to equalize the gain over the frequency range 50 c/s to 3 Mc/s. See also 2552 of 1951 (Bridgewater).

621.397.5 **823**

Velocity-Modulation in Television-Image Reproduction.—A. B. Thomas. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, p. 1341.) Comment on paper abstracted in 2296 of 1951 (Honnell & Prince), pointing out that the method therein described is not velocity modulation, but could more suitably be described by some such term as 'displacement modulation'.

621.397.5 : 535.62 **824**

Alternative Approaches to Color Television.—D. G. Fink. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1124–1134.) Review of principles, capabilities and limitations of the field-sequential and colour-subcarrier systems of colour television.

621.397.5 : 535.62 **825**

Color Television and Colorimetry.—W. T. Wintringham. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1135–1172.) An outline of modern 3-colour theory, with discussion of its application to the problems of colour television. 67 references.

621.397.5 : 535.623 **826**

Recent Improvements in Band-Shared Simultaneous Color-Television Systems.—B. D. Loughlin. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1264–1279.) The 'dot-sequential' system of colour television which requires a total bandwidth of only 4 Mc/s is described; a band-shared method is employed. The advantages of a constant-luminance system are discussed and developments are considered which result in improvement in the colour picture itself and also in reception of the transmissions by black-and-white receiving sets. Colour errors due to crosstalk are discussed; these may be largely eliminated by the use of periodic reversals of the colour sequence in the colour subcarrier. This sequence is actually reversed in adjacent lines, so that the opposite colour errors lie close together and are averaged out by the eye.

621.397.5 : 535.623 **827**

Analysis of Dot-Sequential Color Television.—N. Marchand, H. R. Holloway & M. Leifer. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1280–1287.) See 465 of 1951.

621.397.5 : 535.623 **828**

A New Technique for Improving the Sharpness of Television Pictures.—P. C. Goldmark & J. M. Hollywood. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1314–1322.) In a bandwidth-limited television system the rise time of a step input can be reduced by adding to the signal another waveform derived from it by nonlinear circuit arrangements. Methods of doing this are discussed and results achieved are described.

621.397.5 : 535.623 **829**

Spectrum Utilization in Color Television.—R. B. Dome. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1323–1331.) The frequency spectrum of the 6-Mc/s channel, now standard in the United States for black-and-white or monochrome television transmissions, may be utilized in several ways for the transmission of colour-television images. The three sets of data associated with colour television systems may be transmitted by time-division multiplex, by frequency-division multiplex, or by combinations of these two methods. One of the latter methods, called 'alternating lows', is discussed in some detail, and some of the working circuits for this method are presented. See also 3131 of 1951.

621.397.5 : 535.623 **830**

Subjective Sharpness of Additive Color Pictures.—M. W. Baldwin, Jr. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1173–1176.) 1951 I.R.E. National Convention paper. Description of tests which indicated that an observer's sensitivity to lack of sharpness in colour pictures is greatest for the green component and least for the blue. In monochrome (white, red, green or blue) the sensitivity is equal to that for the green component in colour pictures.

621.397.5 : 535.623](083.74) **831**

Color Television — U.S.A. Standard.—P. C. Goldmark, J. W. Christensen & J. J. Reeves. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1288–1313.) Section 1 deals with the standards established by the Federal Communications Commission and discusses their colorimetric significance. Section 2 is concerned with the design and performance of typical commercial colour-television receivers. Section 3 describes the modification of existing black-and-white studio equipment to render it suitable for colour television. Section 4 discusses applications of colour television other than for broadcasting and describes industrial colour-television equipment known under the name 'Vericolor'.

621.397.5 : 621.317.755 **832**

Oscillographic Representation of Television Signals.—Sturley. (See 741.)

621.397.5(083.74) **833**

Video Levels in TV Broadcasting.—J. H. Roe. (*Tele-Tech*, Aug. 1951, Vol. 10, No. 8, pp. 45–47 . . 64.) A review of progress in standardizing and measuring the levels of the components of television signals with the object of improving performance and of facilitating the exchange of programmes via land-line networks.

621.397.61 **834**

The Vision Transmitter for the Sutton Coldfield Television Station.—E. A. Nind & E. McP. Leyton. (*Proc. Instn elect. Engrs*, Part III, Nov. 1951, Vol. 98, No. 56, pp. 442–459. Discussion, pp. 465–470.) A general description, with additional details of novel parts of the equipment. Aspects of design that are discussed include the general arrangement of the transmitter, the r.f. and modulation amplifiers and associated circuits, special features of the power supply, control, monitoring and supervisory facilities, and testing equipment.

621.397.61 **835**

Automatic Synchronizing Generator for TV.—C. Ellis. (*TV Engng, N.Y.*, Aug. & Sept. 1951, Vol. 2, Nos. 8 & 9, pp. 20–22, 25 & 22–23.) The master oscillator is a stabilized multivibrator running at twice the line frequency. This is divided by an odd number to produce the field frequency and is halved in another channel to produce the line frequency. The division and gating are performed by binary scaler circuits, multiple feedback being introduced to give the odd-number division. The different required pulse widths are produced by using delay lines.

621.397.61 : 621.326 **836**

Blue TV Lamp Design Report.—R. D. Chipp. (*TV Engng, N.Y.*, Aug. 1951, Vol. 2, No. 8, pp. 16–17, 29.) An incandescent lamp partially enclosed in a translucent blue reflector, and mounted inside an ordinary reflector, provides light with a spectrum suitable for television studio use.

621.397.61 : 621.392.52 **837**

The Vestigial-Sideband Filter for the Sutton Coldfield Television Station.—Cork. (See 626.)

621.397.611.21 **838**

Practical Use of Iconoscopes and Image Orthicons as Film Pickup Devices.—K. B. Benson & A. Ettlinger. (*J. Soc. Mot. Pict. Televis. Engrs*, July 1951, Vol. 57, No. 1, pp. 9–14.) Problems involved in current practice are discussed in relation to fundamental theory.

621.397.62 **839**

The English Electric [Co.] Television Receiver.—D. J. Fewings. (*J. Televis. Soc.*, Jan./March 1951, Vol. 6, No. 5, pp. 184–192.) The circuit design is fully described.

621.397.62 : 621.385.832 **840**

The 'Ion Spot' Problem in Television.—L. Chrétien. (*T.S.F. pour Tous*, June 1951, Vol. 27, No. 272, pp. 221–225.) The mechanism causing staining of the screen in c.r. tubes is discussed, and known remedies are described.

621.397.62 : 621.396.615.17 **841**

Timebase for Television Receivers.—E. Kinne. (*Funk u. Ton*, July 1951, Vol. 5, No. 7, pp. 429–434.)

621.397.621.2 **842**

The Design and Operation of Television Cathode-Ray Tubes.—L. S. Allard. (*Electronic Engng*, Aug. 1951, Vol. 23, No. 282, pp. 292–297.) Discussion with special reference to electron guns and deflection systems.

621.397.621.2 : 535.623 **843**

Methods Suitable for Television Color Kinescopes.—E. W. Herold. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1177–1185; *RCA Rev.*, Sept. 1951, Vol. 12, No. 3, Part II, pp. 445–465.) A brief description of various practical systems involving excitation of suitable phosphors by an electron beam is given under the following headings: accurate beam-scanning method; signal control by scanning-beam position; adjacent image method; multiple-colour phosphor screen; beam control at phosphor screen for changing colour; and direction-sensitive colour screens.

621.397.621.2 : 535.623 **844**

A Three-Gun Shadow-Mask Color Kinescope.—H. B. Law. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1186–1194; *RCA Rev.*, Sept. 1951, Vol. 12, No. 3, Part II, pp. 466–486.) The three phosphor colours are arranged in groups of three dots forming an equilateral triangle, and each dot is illuminated by one only of the beams from three electron guns. A thin perforated metal sheet close to the screen has one hole for each trio of phosphor dots; the electron beams are inclined to one another so that each beam as it scans falls on only one dot of the trio. The design geometry of the mask and screen arrangements for maximum efficiency of operation are considered. Construction details of the assembly are given. Experimental tubes have been demonstrated successfully.

621.397.621.2 : 535.62 **845**

A One-Gun Shadow-Mask Color Kinescope.—R. R. Law. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1194–1201; *RCA Rev.*, Sept. 1951, Vol. 12, No. 3, Part II, pp. 487–502.) Colour selection is accomplished by controlling the direction of incidence of a single electron beam at a screen so designed that the colour of light emitted is determined by the angle of incidence. The beam may be shared in time sequence or continuously between the three primary colours. The chief problems associated with this system are in the design of the electron-optical system for deflecting the beam into different colour positions, and, for sequential presentation, in the blanking-off of the beam between different colour positions. Practical solutions of these and other problems are described.

621.397.621.2 : 535.623 846

A 45-Degree Reflection-Type Color Kinescope.—P. K. Weimer & N. Rynn. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1201–1211; *RCA Rev.*, Sept. 1951, Vol. 12, No. 3, Part II, pp. 503–526.) A single electron beam scans, at an angle of incidence of 45°, the back of a perforated metal plate which is coated with red, green and blue phosphor strips on the front. It is mounted parallel to a glass plate coated with a transparent conducting film. The electrons passing through the slots are reflected back on to the phosphors by an electric field applied between the plates, and variation of this field shifts the beam from one colour phosphor to another. Features of this system and its variants are simplicity of screen construction, small colour-switching power required, and automatic registry of the three colours. Good results have been obtained with experimental tubes.

621.397.621.2 : 535.623 847

A Grid-Controlled Color Kinescope.—S. V. Forgue. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1212–1218; *RCA Rev.*, Sept. 1951, Vol. 12, No. 3, Part II, pp. 527–541.) A series of closely spaced screens is used, each coated with a different colour phosphor and separated from each other by control grids whose potentials determine which phosphor is scanned. Individual excitation, or any combination of the primary colours may thus be obtained. Details of screen design and construction are considered. Two- and three-colour experimental tubes have been operated with the R.C.A. colour-system signal.

621.397.621.2 : 535.623 848

Development and Operation of a Line-Screen Color Kinescope.—D. S. Bond, F. H. Nicoll & D. G. Moore. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1218–1230; *RCA Rev.*, Sept. 1951, Vol. 12, No. 3, Part II, pp. 542–567.) The screen consists of a cyclic arrangement of many narrow parallel phosphor strips of the three primary colours. In the method principally investigated the scanning lines are parallel to the phosphor strips, a stepped deflection voltage being used to produce scanning of each of the three adjacent phosphors during each line of the scan. The required registration of scanning lines with the screen elements is obtained by means of a servo circuit deriving control information from secondary-emission-signal areas on the screen. Tubes of 16-in. envelope diameter have given pictures of high horizontal definition and adequate colour purity.

621.397.621.2 : 535.623 849

Phosphor-Screen Application in Color Kinescopes.—N. S. Freedman & K. M. McLaughlin. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1230–1236; *RCA Rev.*, Sept. 1951, Vol. 12, No. 3, Part II, pp. 568–582.) Describes the technique of preparing c.r. tube screens composed of dots or lines of three different colour phosphors. The pattern for each colour is produced by forcing the phosphor, suspended in a lacquer, through a gelatine stencil supported by a steel mesh; it is located to an accuracy of better than 0·001 in. over the entire screen.

621.397.621.2 : 535.623 850

Three-Beam Guns for Color Kinescopes.—H. C. Moodey & D. D. Van Ormer. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1236–1240; *RCA Rev.*, Sept. 1951, Vol. 12, No. 3, Part II, pp. 583–592.) The gun principally described consists of three guns aligned with axes parallel, equidistant from the assembly axis, and evenly spaced round it. Separate leads are provided for cathodes and grids 1 and 2 of each gun; the potentials of grids 3 and 4 may be varied to maintain beam focus and convergence during scanning. Construction details of this gun are given, and also of certain other types.

621.397.621.2 : 535.623 851

Mechanical Design of Aperture-Mask Tri-color Kinescopes.—B. E. Barnes & R. D. Faulkner. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1241–1245; *RCA Rev.*, Sept. 1951, Vol. 12, No. 3, Part II, pp. 593–602.)

621.397.621.2 : 535.623 852

Effects of Screen Tolerances on Operating Characteristics of Aperture-Mask Tri-color Kinescopes.—D. D. Van Ormer & D. C. Ballard. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1245–1249; *RCA Rev.*, Sept. 1951, Vol. 12, No. 3, Part II, pp. 603–611.)

621.397.621.2 : 535.623 853

Deflection and Convergence in Color Kinescopes.—A. W. Friend. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1249–1263; *RCA Rev.*, Sept. 1951, Vol. 12, No. 3, Part II, pp. 612–644.) A method is described for obtaining deflection with satisfactory convergence of the beam when a shadow-mask colour kinescope is used. The convergence at each point of the screen was studied with the aid of a conical scan produced by a rotating magnetic field; it could be corrected by adjustments of the deflection yoke or of the convergence lens. A method applicable to single-beam line-screen colour kinescopes is also described briefly.

621.397.7 854

The Sutton Coldfield Television Broadcasting Station.—P. A. T. Bevan & H. Page. (*Proc. Instn elect. Engrs*, Part III, Nov. 1951, Vol. 98, No. 56, pp. 416–441. Discussion, pp. 465–470.) A description is given of the design, construction and service performance of the station, which operates on sound and vision carrier frequencies of 58·25 Mc/s and 61·75 Mc/s respectively. The relation of the operating channel to the frequency allocation plan for the United Kingdom and the reasons for using vestigial-sideband vision transmission are discussed. The choice of site, the sources of power and the layout of the buildings are considered.

The vision transmitter is of the high-power modulated type giving a peak-white power output of 42 kW, and the amplitude/frequency characteristic is shaped by means of a vestigial-sideband filter. The sound transmitter has a final stage of the earthed-grid coaxial-line power-amplifier type capable of being tuned over the band 41–68 Mc/s and giving a power output of 12 kW. The control and cooling equipment and the measured performance characteristics for both transmitters are described.

The vision and sound signals are supplied by separate transmission lines to a combining diplexer at the top of a 750-ft mast and are radiated from the same aerial system. This consists of two rings of vertical folded dipoles, each ring having four units, the phase changing progressively round the rings in steps of 90°. The method of obtaining this phase relation and of adjusting the admittance/frequency characteristic of the complete system to give a voltage s.w.r. of better than 0·96 over the required band is described. A field-strength map of the service area is included.

621.397.82 **855**

Observer Reaction to Low-Frequency Interference in Television Pictures.—A. D. Fowler. (*Proc. Inst. Radio Engrs*, Oct. 1951, Vol. 39, No. 10, pp. 1332–1336.) Report of tests to determine how much low-frequency interference can be tolerated in black-and-white television pictures. See also 751 of 1951 (Mertz et al.).

621.397.828 **856**

The Overtone Crystal Oscillator against TVI.—E. J. Pearcey. (*Short Wave Mag.*, July 1951, Vol. 9, No. 5, pp. 278–282.) Consideration of the choice of fundamental frequency of the crystal in a h.f. or v.h.f. amateur transmitter and the use of overtone operation to minimize interference with television reception from the British stations.

TRANSMISSION

621.396.619 : 621.319.53 **857**

High-Power Pulse Generator with Controlled Spark-Gap.—Prokott. (See 612.)

VALVES AND THERMIONICS

621.383.2 **858**

Lithium-Antimony Photoelectric Cathodes. — N. Schaetti & W. Baumgartner. (*Le Vide*, July/Sept. 1951, Vol. 6, Nos. 34/35, pp. 1041–1045.) The properties of Li-Sb and Cs-Sb photocathodes are compared. Because of their inherently lower thermionic emission, the former are more suitable for use in photomultipliers for scintillation counters.

621.383.2.032.21 : 537.312.5 **859**

Photoconductivity of Composite Photoemissive Cathodes.—S. Pakswer & W. O. Reed. (*J. appl. Phys.*, July 1951, Vol. 22, No. 7, pp. 987–988.) Discussion of investigations on semitransparent photoemissive coatings of Ag-O-Cs, Sb-Cs and PbS-Cs.

621.383.4 : 546.817.241 **860**

Photoconductivity in the Infrared Region of the Spectrum: Part 1—The Preparation and Properties of Photoconductive Films of Lead Telluride.—O. Simpson & G. B. B. M. Sutherland. (*Philos. Trans. A*, 16th Aug. 1951, Vol. 243, No. 872, pp. 547–564.) "The method of preparation of photoconductive films of lead telluride is described. Details are given of the construction of cells suitable for infrared detection in spectroscopic applications. Lead telluride is not photosensitive at room temperature, but is strongly photoconductive at temperatures in the region of -190°C. The conductivity of lead telluride as a function of the applied voltage, and the wave-length and intensity of illumination has been investigated, for seven films of widely different conductivity, at liquid-air temperature. The application of the photoconductive effect to infrared detection is discussed, and attention is drawn to the effect of any background of thermal radiation on the performance of a cooled photoconductor."

621.383.4 : 546.817.241 **861**

Photoconductivity in the Infrared Region of the Spectrum: Part 2—The Mechanism of Photoconductivity in Lead Telluride.—O. Simpson. (*Philos. Trans. A*, 16th Aug. 1951, Vol. 243, No. 872, pp. 564–584.) "A method is described by which thin semi-conducting films of nearly stoichiometric lead telluride can be prepared by evaporation, in a sequence with increasing impurity of lead. The conductivity and infra-red photoconductivity of the specimens has been investigated as a function of temperature and of lead impurity. It is found that the magnitude of the photo-effect is a function of the dark conductivity, and depends only on the quantity of excess lead. The absorption of oxygen at room temperature is equivalent to the removal of excess lead; the presence of oxygen is not a requirement for the appearance of photoconductivity. These observations are used to draw conclusions concerning the mechanism of the photoconductivity. It is shown that all the phenomena can be explained by a single lattice model, without recourse to internal potential barriers or inhomogeneities in the composition of the samples."

621.385+621.396.6 **862**

New Radio Components in the World Market.—Alixant. (See 628.)

621.385 **863**

The JETEC Approach to the Tube-Reliability Problem.—J. R. Steen. (*Proc. Inst. Radio Engrs*, Sept. 1951, Vol. 39, No. 9, pp. 998–1000.) An outline of statistical methods of assessing reliability and of procedures considered by the Joint Electron-Tube Engineering Council as necessary for the production of more reliable types of valve.

621.385.011 **864**

On the Rigorous Calculation of the Transconductance of Planar Systems on the Basis of Potential Theory.—O. Heymann. (*Frequenz*, March & April 1951, Vol. 5, Nos. 3 & 4, pp. 57–62 & 97–107.) The method developed avoids mathematical difficulties of the image techniques. Neglecting space charge, the anode and cathode are represented as plane surfaces, the grid as an infinite series of parallel equidistant wires. The potentials due to the charges on these surfaces are expressed in Fourier series. Treating these charges as individual Maxwell grids and inserting the boundary conditions to be satisfied at the three electrodes, an infinite set of equations is derived from which the approximate values of the Fourier coefficients can be calculated. Examples illustrate the value of the general equations.

621.385.012.6 **865**

Electron-Tube Performance with Large Applied Voltages.—A. E. S. Mostafa. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, p. 1432.) Correction to paper abstracted in 1517 of 1951.

621.385.029.62/.63 **866**

Miniature Traveling-Wave Tube.—R. Adler. (*Electronics*, Oct. 1951, Vol. 24, No. 10, pp. 110–113.) The operation and characteristics of an experimental model are described. Gain per unit length and noise figures are satisfactory for miniature wide-band amplifier valves working at frequencies between 100 and 1 000 Mc/s. Operating voltages and currents are similar to those required for other small valves. Various modifications of the experimental model are discussed.

621.385.029.62/.63 **867**

Traveling-Wave Amplification by means of Coupled Transmission Lines.—W. E. Mathews. (*Proc. Inst. Radio Engrs*, Sept. 1951, Vol. 39, No. 9, pp. 1044–1051.) The theory of interaction between coupled transmission lines moving relative to each other is developed, and conditions yielding waves increasing exponentially with distance are found. The case of lossless lines, one moving and one stationary, is analysed in detail, the results being applicable to the helix travelling-wave valve. The most fundamental qualitative finding is that amplification results from interaction between the forward wave on the stationary line and the backward wave on the moving line, so that when the translational velocity of the moving line is sufficiently greater than the natural propagation velocity of that line, the backward wave is actually made to move forward in approximate synchronism with the forward wave on the stationary line. Gain occurs over a small but finite range of the translational velocity, maximum gain being obtained when the two waves concerned are very nearly in perfect synchronism. The theory suggests the possibility of travelling-wave amplification in systems other than electrical, and a mechanical travelling-wave oscillator has been built; this was demonstrated at the I.R.E. Conference on Electron Devices, Princeton, June 1949.

621.385.032.216 **868**

On the Initial Decay of Oxide-Coated Cathodes.—T. Hibi & K. Ishikawa. (*J. appl. Phys.*, July 1951, Vol. 22, No. 7, pp. 986–987.) Investigation of the effect produced on the decay by heating getter deposits in valves.

621.385.032.216 : 546.841-3 **869**

Conductivity and Other Electrical Properties of Thoria in Vacuo.—G. Mesnard & R. Uzan. (*Le Vide*, July/Sept. & Nov. 1951, Vol. 6, Nos. 34/35 & 36, pp. 1052–1062 & 1091–1097.) Details are given of experimental valves used for the measurement of the resistance, thermoelectric e.m.f. and thermal conductivity of thoria. The purest available material was used; this was initially in the form of an amorphous powder, which crystallized on heat treatment. Results are presented and discussed in relation to possible mechanisms involved. See also 2730 of 1951 (Mesnard).

621.385.3 : 546.289 : 621.396.822 **870**

Theory of Noise in the Transistor.—Y. Watanabe & N. Honda. (*Sci. Rep. Res. Inst. Tohoku Univ., Ser. B*, March 1951, Vol. 1/2, No. 3, pp. 313–325.) The noise power produced in the collector path of a transistor is considered theoretically. The magnitude and frequency dependence of this noise, which is due to the fluctuation of the number of holes in the bulk germanium, is shown to agree with experimental results.

621.385.3 : 621.396.615.14 **871**

Electron Transit Time Affected by the Initial Velocity of Emitted Electrons from the Cathode and the Field Irregularity around the Grid Wires in a Triode.—Y. Koike & S. Yamanaka. (*Sci. Rep. Res. Inst. Tohoku Univ., Ser. B*, March 1951, Vol. 1/2, No. 3, pp. 349–364.) Higher values are obtained for the limiting frequency of a triode oscillator than are expected from theory. Two factors, the initial velocity of electrons emitted from the cathode and the irregular field around the grid, are analysed theoretically to show their effect in decreasing the electron transit time.

621.385.38 **872**

Gas Discharge Tubes.—(*Wireless World*, July 1951, Vol. 57, No. 7, pp. 293–294.) Brief account of operation and application of the 'plasmatron' [see also 2869 of 1951 (Johnson)], a French valve described by Besson (873 below), and a corona-discharge stabilizer valve.

621.385.38 **873**

A New Amplifier Arrangement.—R. Besson. (*Toute la Radio*, May 1951, No. 155, pp. 110–112.) Description of the construction and operation of a gas-discharge triode with continuous grid control, and its application in an amplifier for photoelectric currents. See also 2869 of 1951 (Johnson).

621.385.38 **874**

A High-Current Thyratron.—A. W. Coolidge, Jr. (*Elect. Engng, N.Y.*, Aug. 1951, Vol. 70, No. 8, pp. 698–699.) 1951 A.I.E.E. Winter General Meeting paper. Description of the thyratron Type GL-5855, with peak and average current ratings of 150 and 12·5 A respectively, a 2·5-V cathode and an anode voltage rating of 1 500 V. Construction details are given, one feature being the use of rigid strap connections instead of a valve base.

621.385.38 **875**

The Thyratron Grid Spike.—M. P. Givens. (*Rev. sci. Instrum.*, July 1951, Vol. 22, No. 7, pp. 533–534.) When a thyratron fires, the control grid assumes a high positive potential for a short time. The explanation is that the grid is then acting only as a probe in the tube and rises rapidly to anode potential. An experiment confirming this is described.

621.385.832 **876**

An Electrostatic-Tube Storage System.—A. J. Lephakis. (*Proc. Inst. Radio Engrs*, Nov. 1951, Vol. 39, No. 11, pp. 1413–1415.) Binary pulses are stored as an array of discrete spots of charge, using a 2-channel system with two M.I.T. e.s. storage tubes (1034 of 1951). The sequence of incoming pulses is preserved during storage but the time relation of pulses recovered from storage is determined by an independent pulse source. The capacity of each channel is 256 pulses; upper frequency limits are respectively $3 \cdot 3 \times 10^4$/sec and 7×10^4/sec for the storage of pulses and for supplying stored pulses.

621.396.615.141.2 **877**

The Magnetron in the Condition of Static Space Charge: Magnetrons with Axial Anode.—J. L. Delcroix. (*C. R. Acad. Sci., Paris*, 20th Aug. 1951, Vol. 233, No. 8, pp. 546–547.) The study of the bidromic state for this type of magnetron does not involve any of the difficulties associated with the classical magnetron (i.e. with axial cathode). The electron transit time remains finite for all values of b/a (where b is the radius of the cut-off surface and a that of the cathode); as b/a approaches unity, the conditions approach those for the plane magnetron.

621.396.615.142.2 **878**

The Effects of Grid Mesh on the Performance Characteristics of Klystrons.—S. Uda & J. Ikeuchi. (*Sci. Rep. Res. Inst. Tohoku Univ., Ser. B*, Jan. 1951, Vol. 1/2, No. 1, pp. 105–116.)

621.396.615.142.2 **879**

Electron Oscillation of the Reflex Klystron.—M. Ishida & Y. Ibaraki. (*Sci. Rep. Res. Inst. Tohoku Univ., Ser. B*, March 1951, Vol. 1/2, No. 3, pp. 327–336.) An electron oscillation, independent of the cavity, is obtained with the parallel-plane electrode structure of a reflex klystron. The characteristics of this oscillation are studied theoretically and experimentally and compared with the velocity-modulation oscillation.

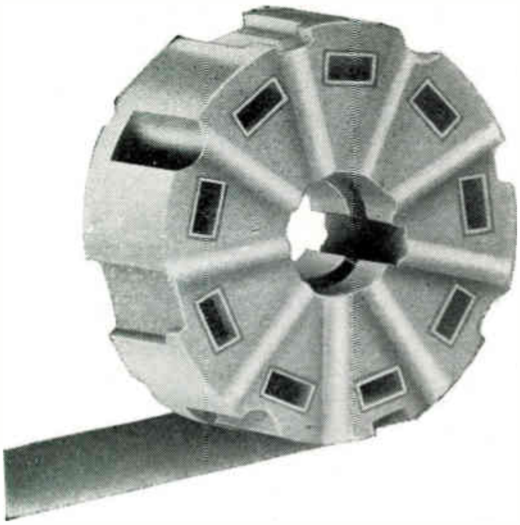
MISCELLANEOUS

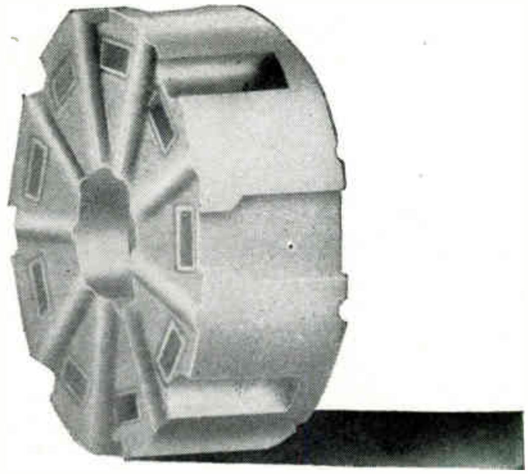
001.891 : 621.396 **880**

University Research in Physics: Part 2—Research in Physics at Cambridge University. Radio Research.—J. A. Teegan. (*Beama J.*, July 1951, Vol. 58, No. 169, pp. 205–209.) A short general account of work in progress, including studies of (*a*) the fading of waves reflected from the ionosphere, (*b*) ionospheric cross-modulation, and (*c*) radiation from the surface of the sun and from galactic and extra-galactic sources.

001.891 : 621.396.029.6 **881**

Study Centre for Microwave Physics: Activities during 1950.—N. Carrara. (*Ricerca sci.*, July 1951, Vol. 21, No. 7, pp. 1161–1165.) Increasing activity at the C.N.R. Centre at Florence is reported; subjects investigated include properties of evanescent waves, absorption of microwaves by ionized gases, acceleration of electrons by means of microwaves, solar noise, microwave measurements, and microwave radio communication.





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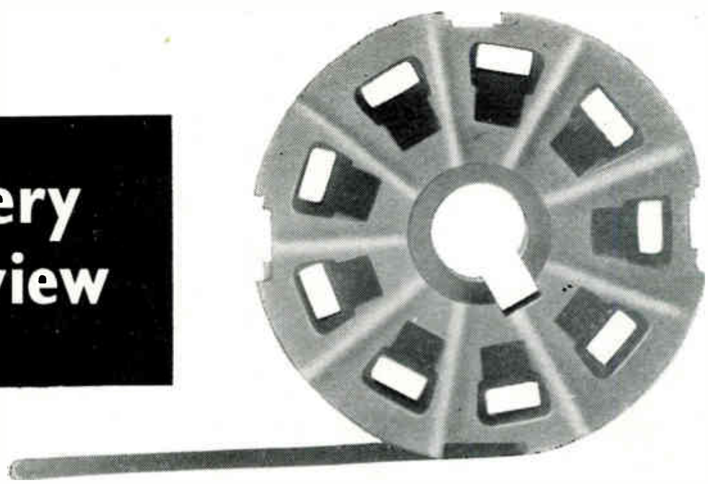

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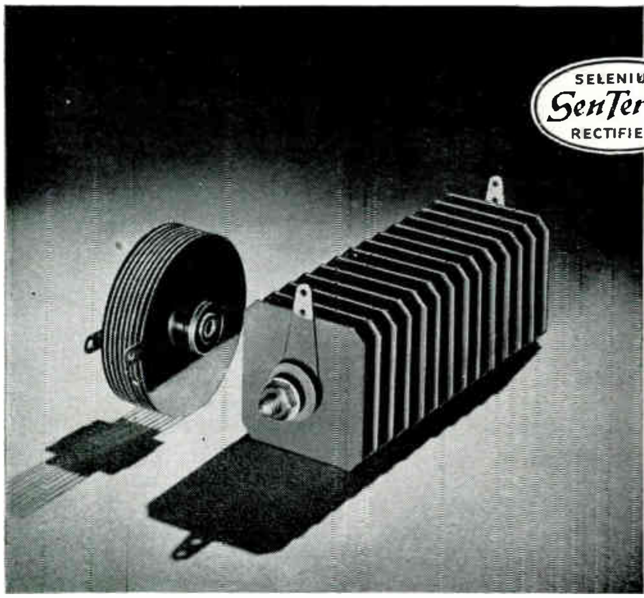

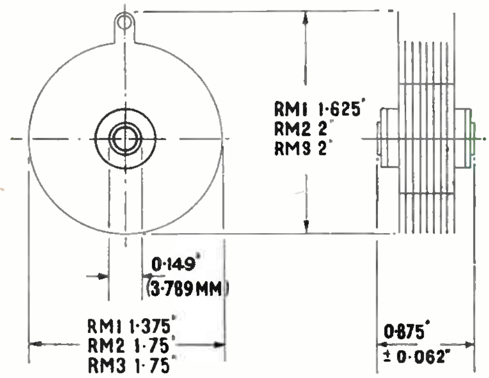

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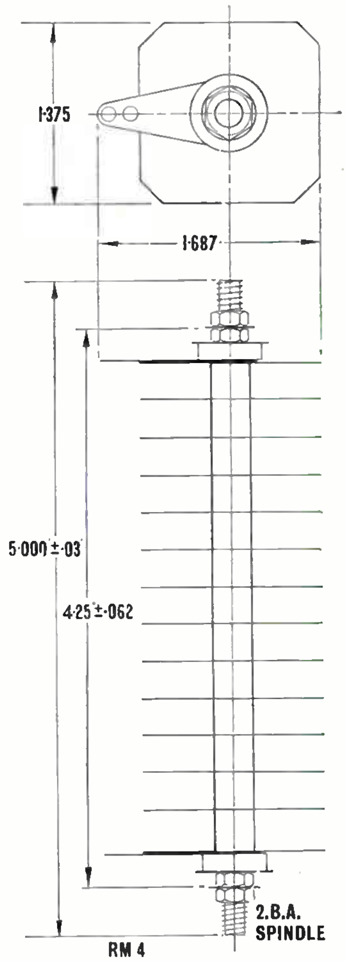

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Maximum input voltage (r.m.s.)	125V		125V		125V		250V		
Maximum peak inverse voltage	350V		350V		350V		700V		
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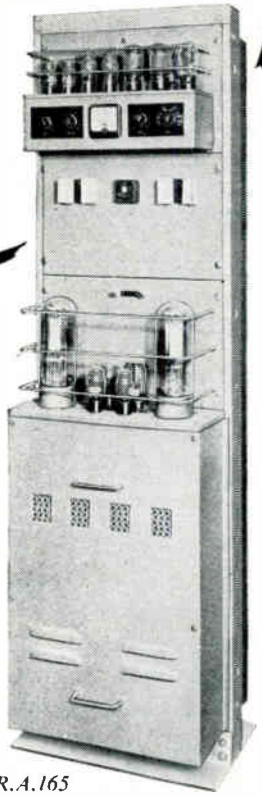
The obvious choice for

RADIO RELAY & HIGH POWER PUBLIC ADDRESS EQUIPMENT



E.M.I. R.A.165
Relay Amplifier

RATING

Filament Voltage (volts)	14.0
Filament Current (amps)	6.5
Maximum Anode Voltage (volts)	3,000
Max. Anode Dissipation (watts)	275
* *Impedance (Ohms)*	2,000
* *Amplification Factor*	16
* *Mutual Conductance (mA/V)*	7

Total emission approx. 4 amps.
* *At Va = 2,000v*
Ia = 150mA
Base: Special 4-pin.

The long life and reliability of the Ediswan V1505 make it the obvious choice for Radio Relay and High Power Public Address Equipment such as the E.M.I. R.A.165 Relay Amplifier. In this equipment a pair of Ediswan V1505's operating in push-pull provide a power output of 1,000 watts.

The Ediswan V1505 is a radiation cooled triode with a directly heated thoriated tungsten filament and anode dissipation of 275 watts.

Full technical details and prices on request

EDISWAN

SPECIAL PURPOSE
VALVES

THE EDISON SWAN ELECTRIC COMPANY LTD., 155 CHARING CROSS ROAD, LONDON, W.C.2

Member of the A.E.I. Group of Companies

E.V.73

Index to Advertisers

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THRUSTING ASIDE
all preconceived ideas!

THE MIGHTY MIDGET, most recent development in the Radio and Electronic field, embodies more than a complete break away from traditional ideas of size. Type W99 Midget Moldseal Metallised Paper Capacitor has the clean, neat finish of an entirely new type of moulding recently developed by Hunt's. Providing hermetic sealing, this Moldseal capacitor is invaluable for use with compact mobile equipment where risk of encountering more than the usual conditions of moisture is incurred.

Though tiny, W99 has a high insulation resistance and self-healing characteristics. Enquiries are welcomed.

WKG. VOLTAGE	CAP. μF.	SIZE
150 D.C.	0.004 to 0.01 0.02 to 0.04	A B
350 D.C.	0.001 to 0.003 0.004 to 0.01	A B
600 D.C.	2.5pF to 0.001 0.002 to 0.004	A B
300 A.C.	0.00005 to 0.001 0.002 to 0.004	A B

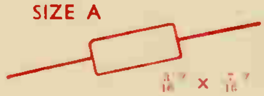
CAP. TOLERANCE: ±20% (closer tolerances are available)
TEMP. RANGE: −40°C to +71°C
I. R. Not less than 20,000 megohms,
SELF HEALING

The Trade Mark of Reliability

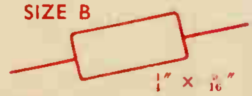
HUNTS CAPACITORS

● *Capacitances up to 1 μF 350V. D.C. wkg. and 2 μF 250V. D.C. wkg. are also available in Miniature Moldseal Metallised Paper Tubulars. Type W48.*

SIZE A



SIZE B



FOR RADIO · ELECTRONIC & INDUSTRIAL USES

ESTD. 1901

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